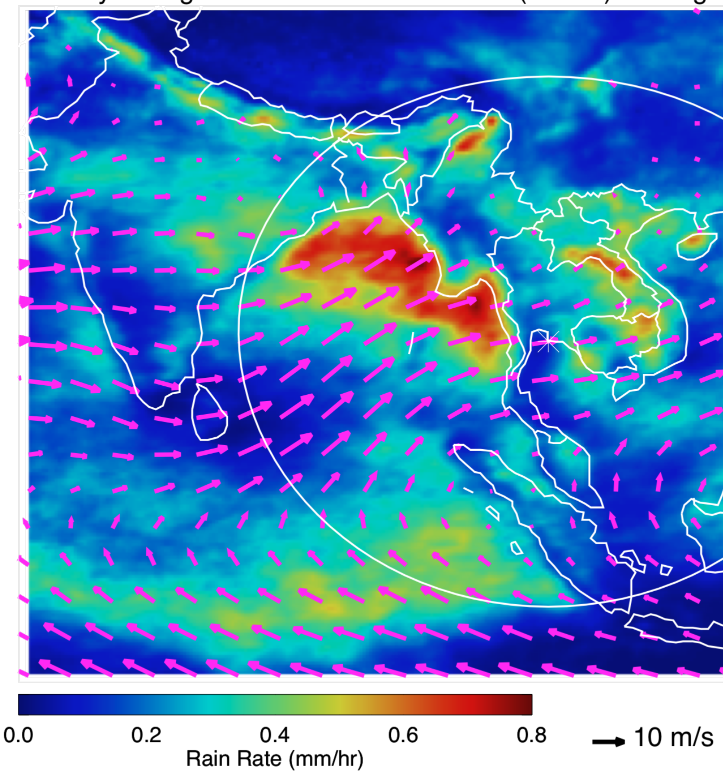
SE Asia Meteorology

Lenny Pfister and Henry Fuelberg

- Mean picture
  1. Circulation
  2. Rainfall
  3. Cold clouds
  4. Lightning
- Diurnal variations
- Interannual variations (ENSO)
- Tropical cyclones
- Intra-Seasonal Variations (week to 90 days)
- Origins of air at upper levels – trajectory climatology
- Utapao weather

9 yearavg 925 mb Flow and rainrate (mm/hr) for August

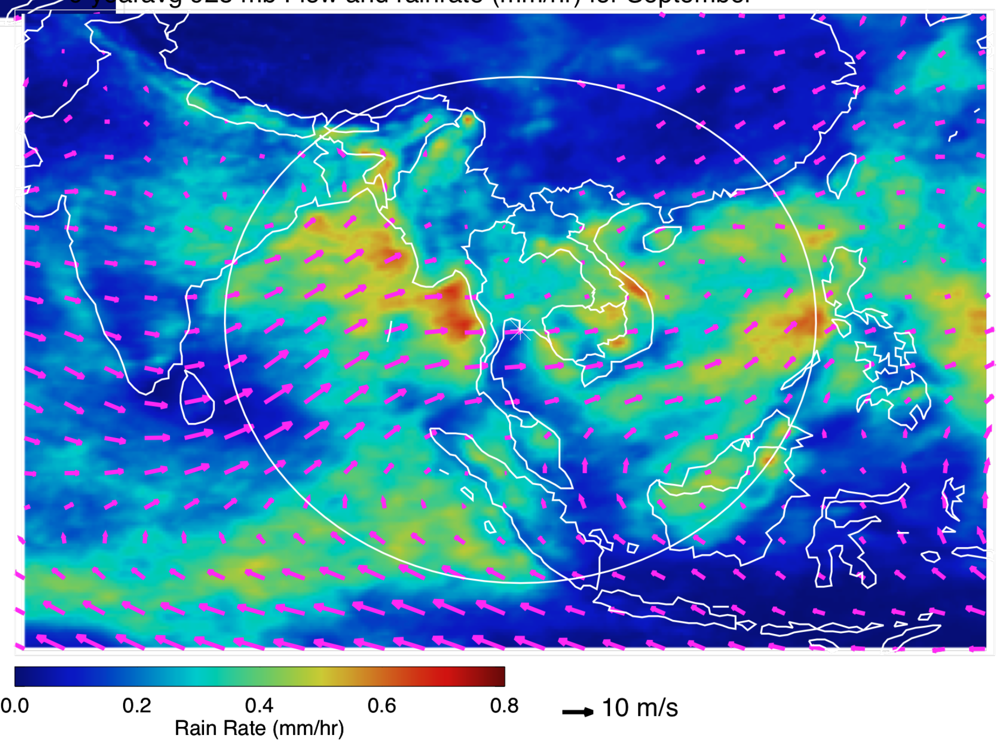


Low level monsoon flow
weakens in September

Rainfall shifts to east,
and south

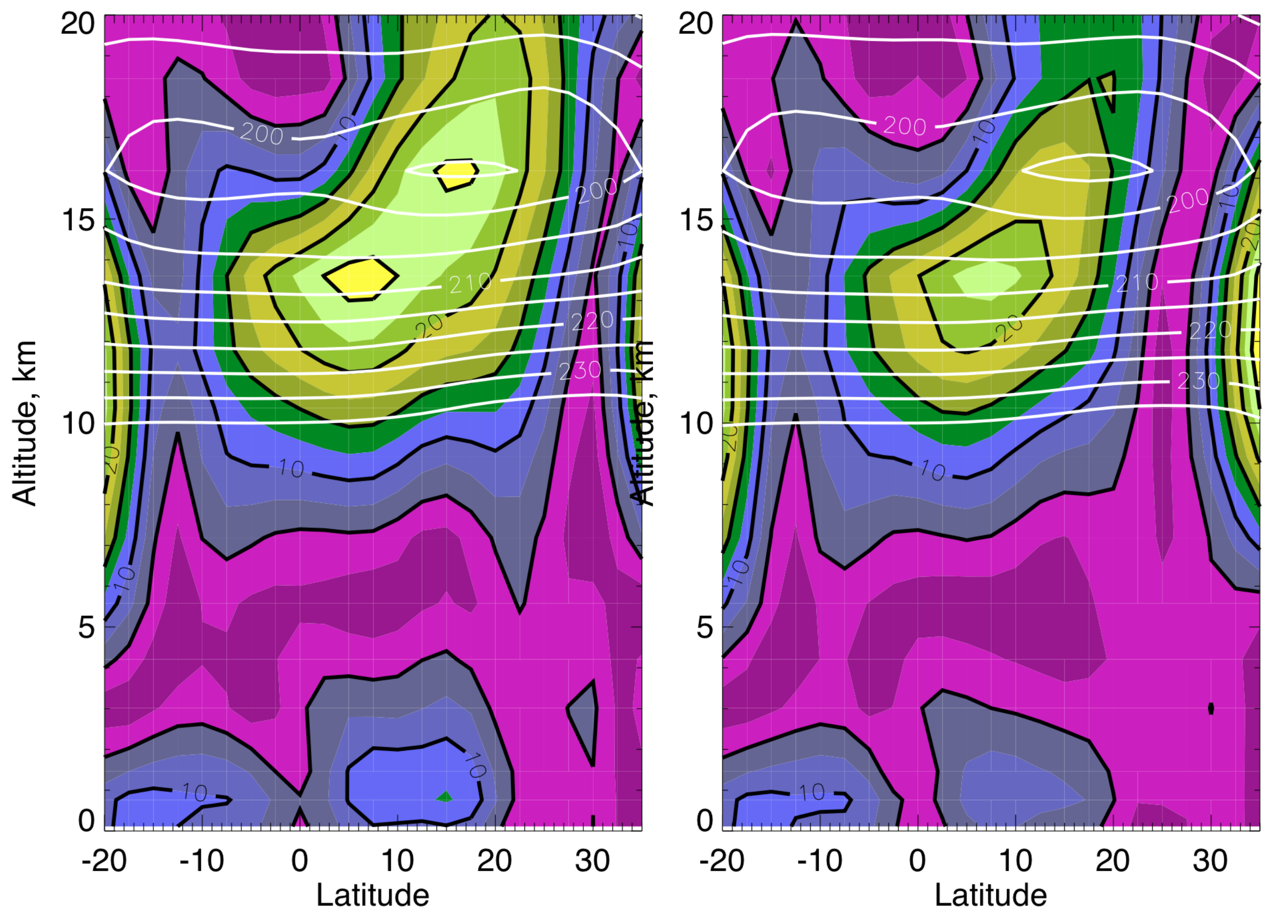
High rainfall as low level
Wind impinges on land

9 yearavg 925 mb Flow and rainrate (mm/hr) for September



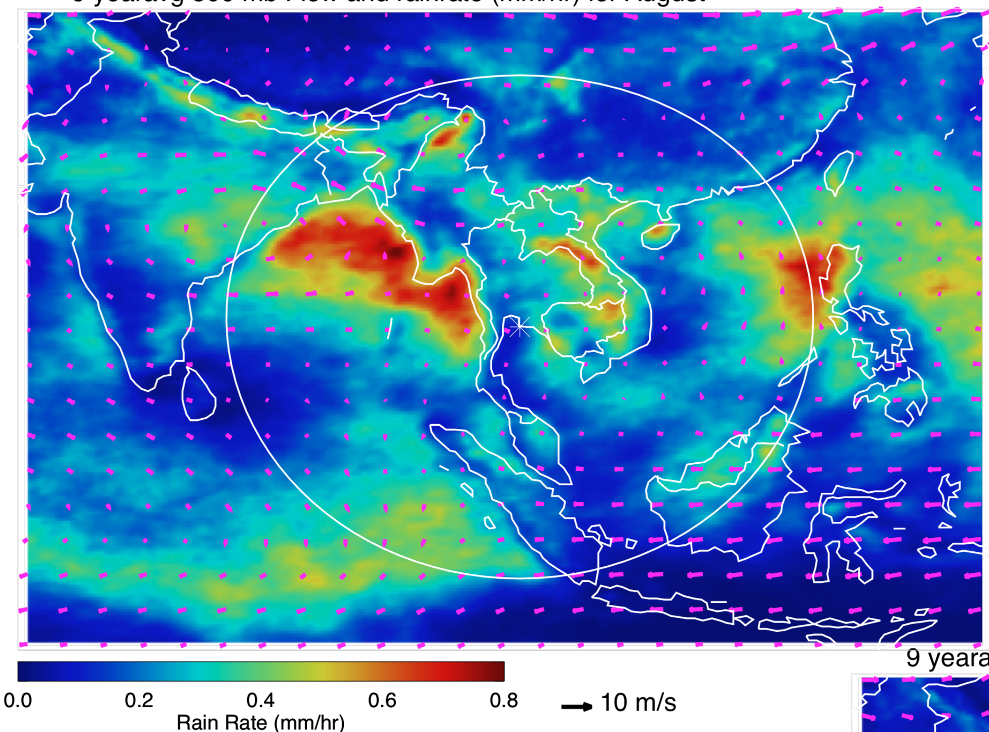
Wind and Temperature Cross Sections at 80 East

August (21 years) September (21 years)

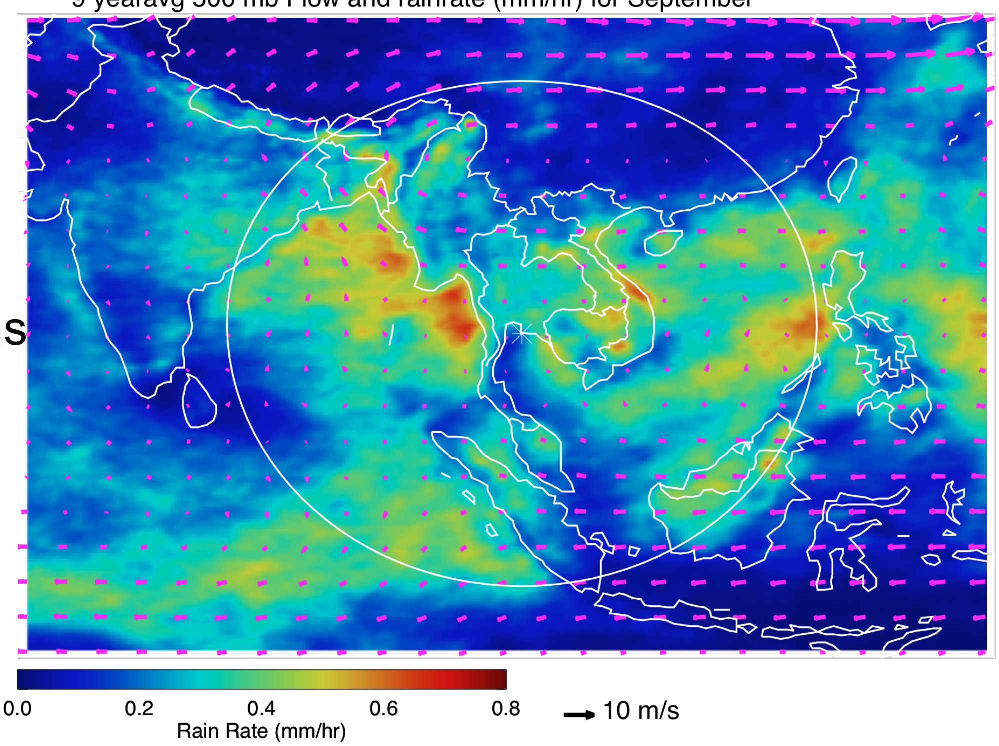


Note weaker low and upper level flow in September;

9 yearavg 500 mb Flow and rainrate (mm/hr) for August



9 yearavg 500 mb Flow and rainrate (mm/hr) for September



Weak flow at mid levels. Fluctuations in flow will determine origin of the air, as opposed to lower and upper levels where flow is strong

Precipitation ≠ deep clouds !

13 years Aug-Sep Climatology

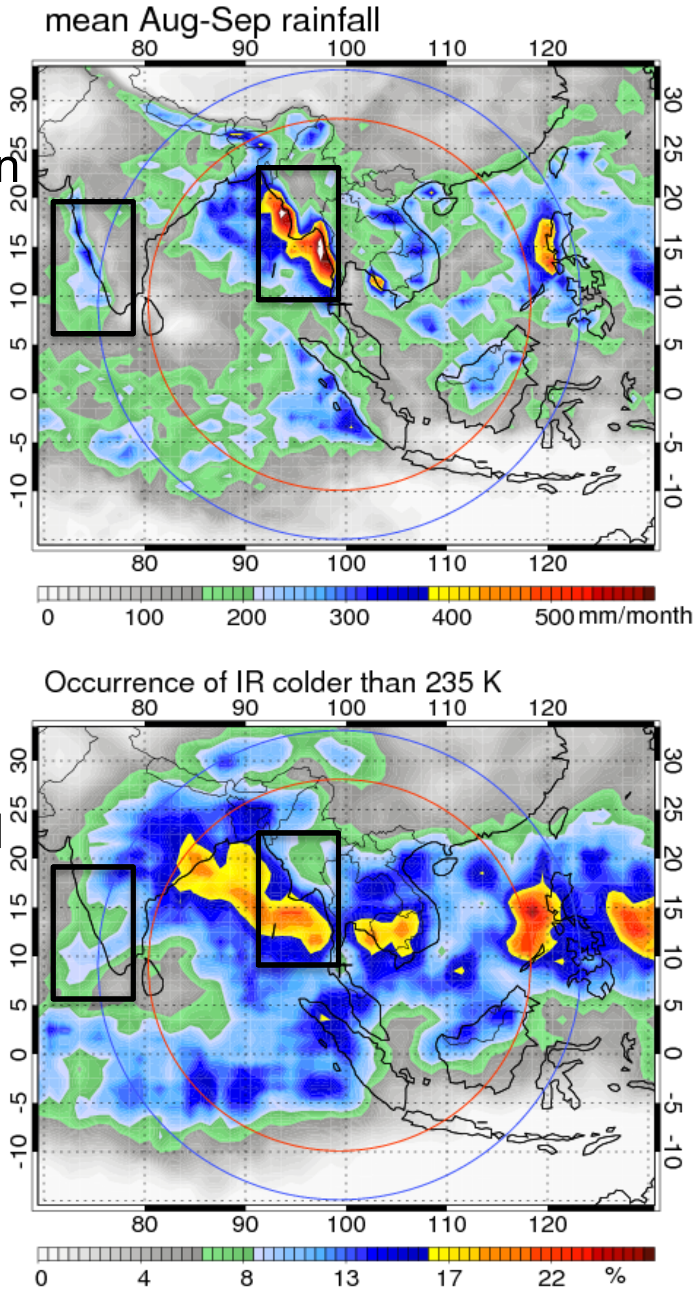
Thanks to Chuntao Liu

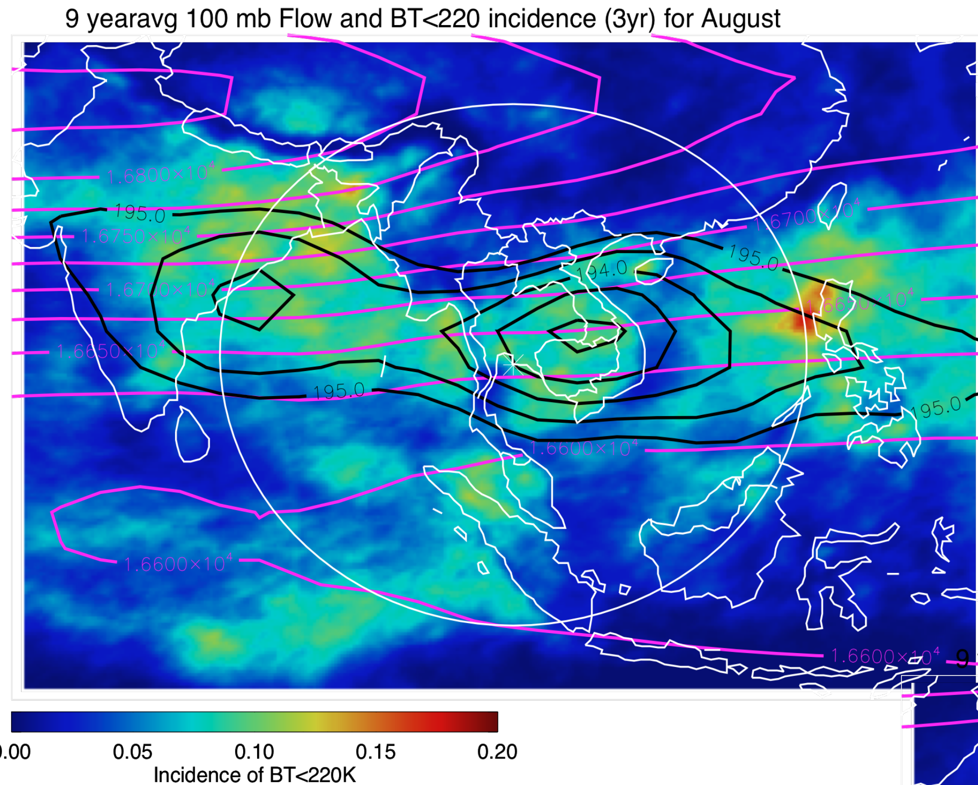
Precipitation

Precipitation particle at 12 km

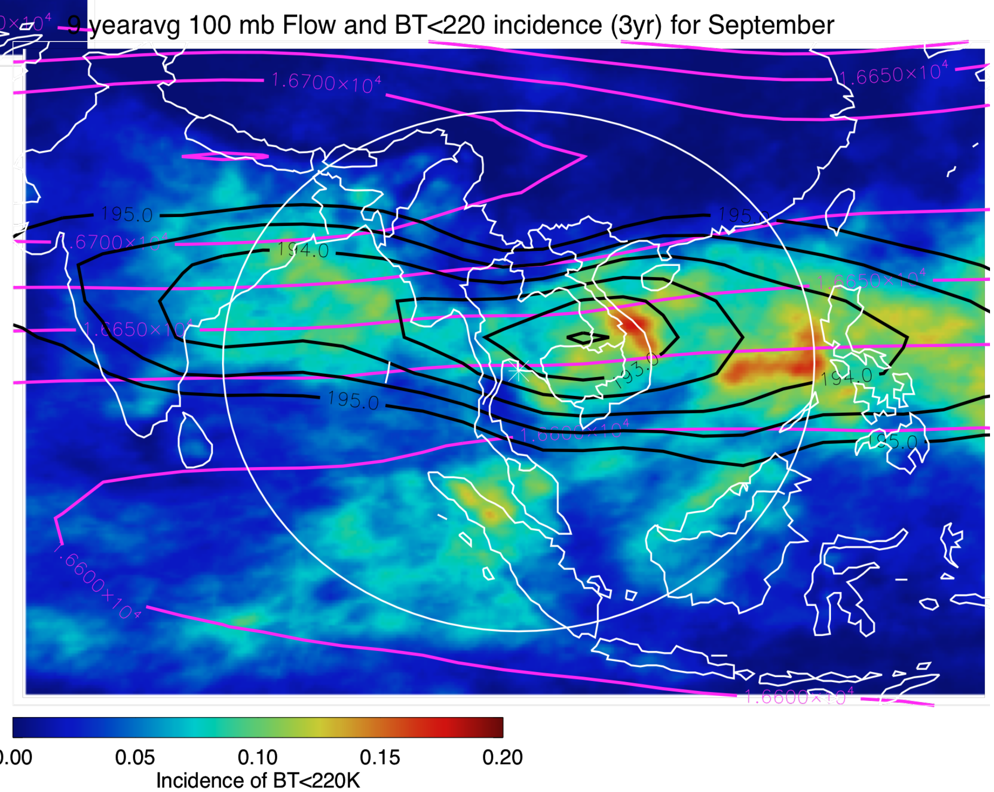
Cold cloud Top T -38°C ~ 10 km

Very Cold cloud Top T -63°C ~ 13.5 km





100mb (about 16.8km altitude)

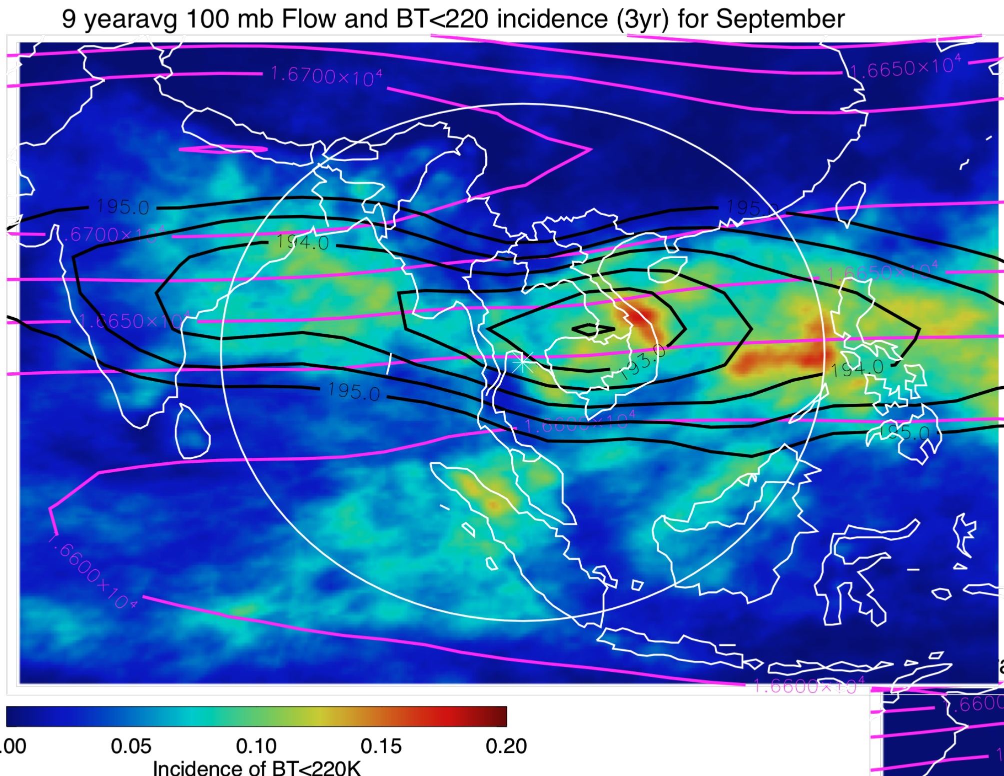


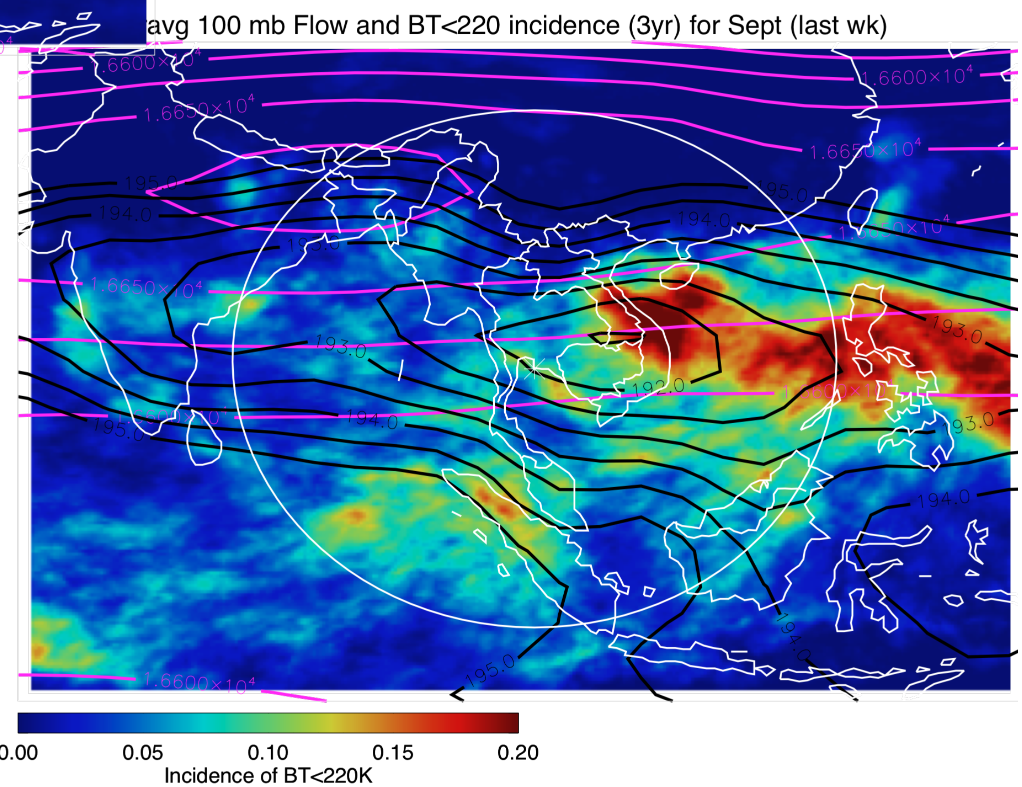
Easterly jet narrows at this altitude compared with August.

Cold temperature coincides roughly with convection, moving eastward in Sept.

Incidence of cold cloud near center of anticyclone decreases in Sept.

Anticyclone and easterly jet weaken in September

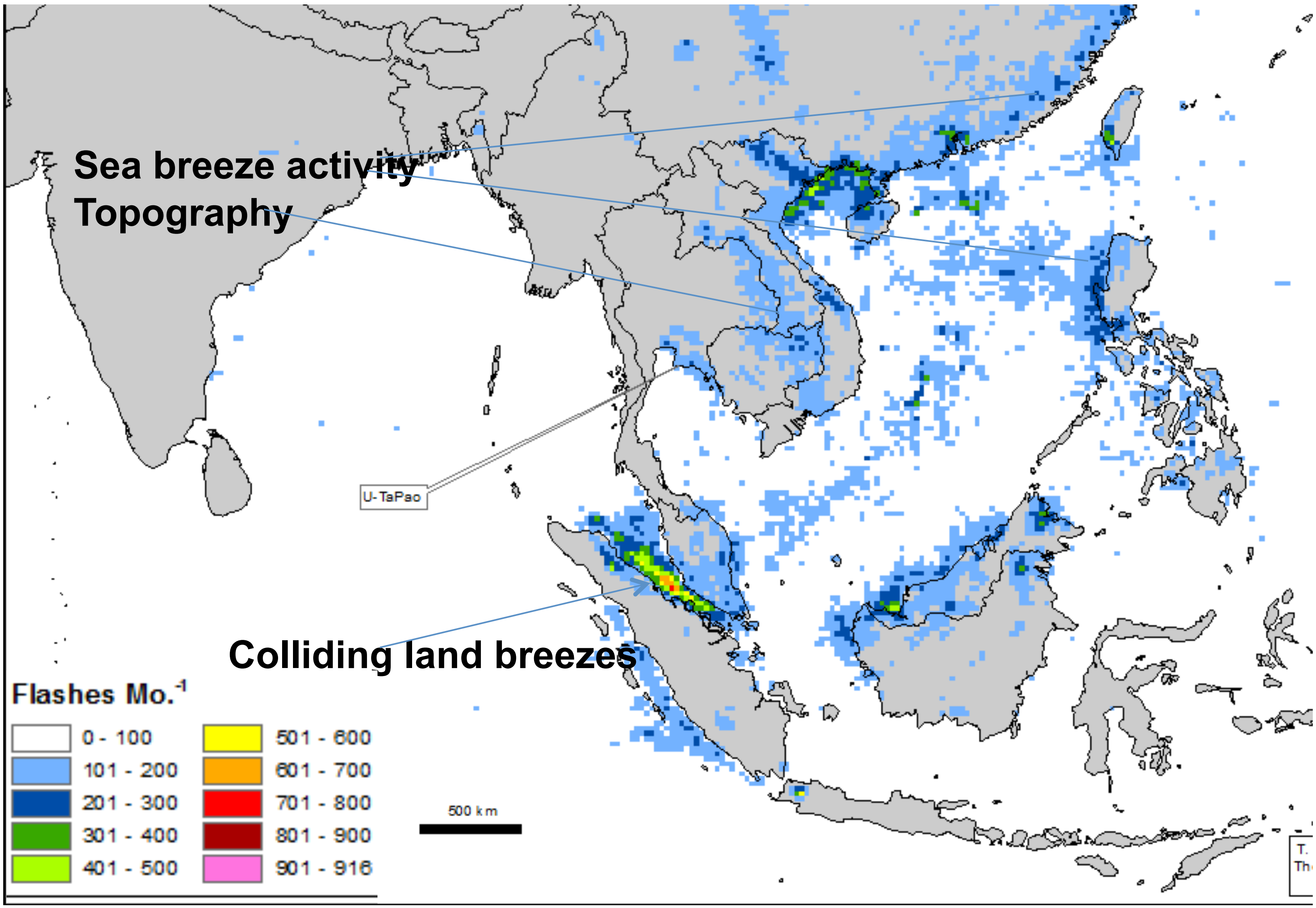




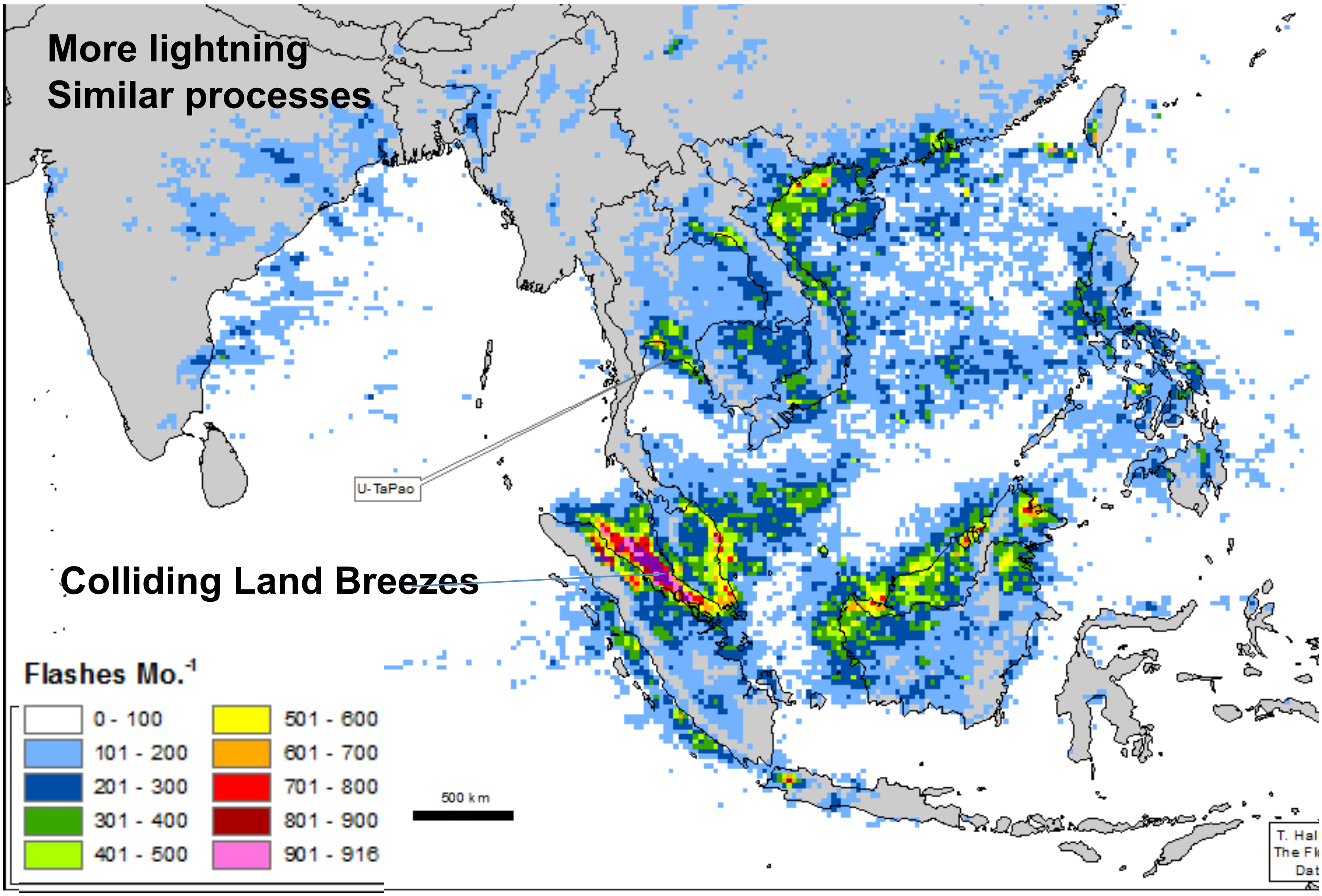
Comparing last week (right) in Sept to entire month. Can see further movement of convection to east – BOB convection is substantially less.

Anticyclone is further weakened, but still present.

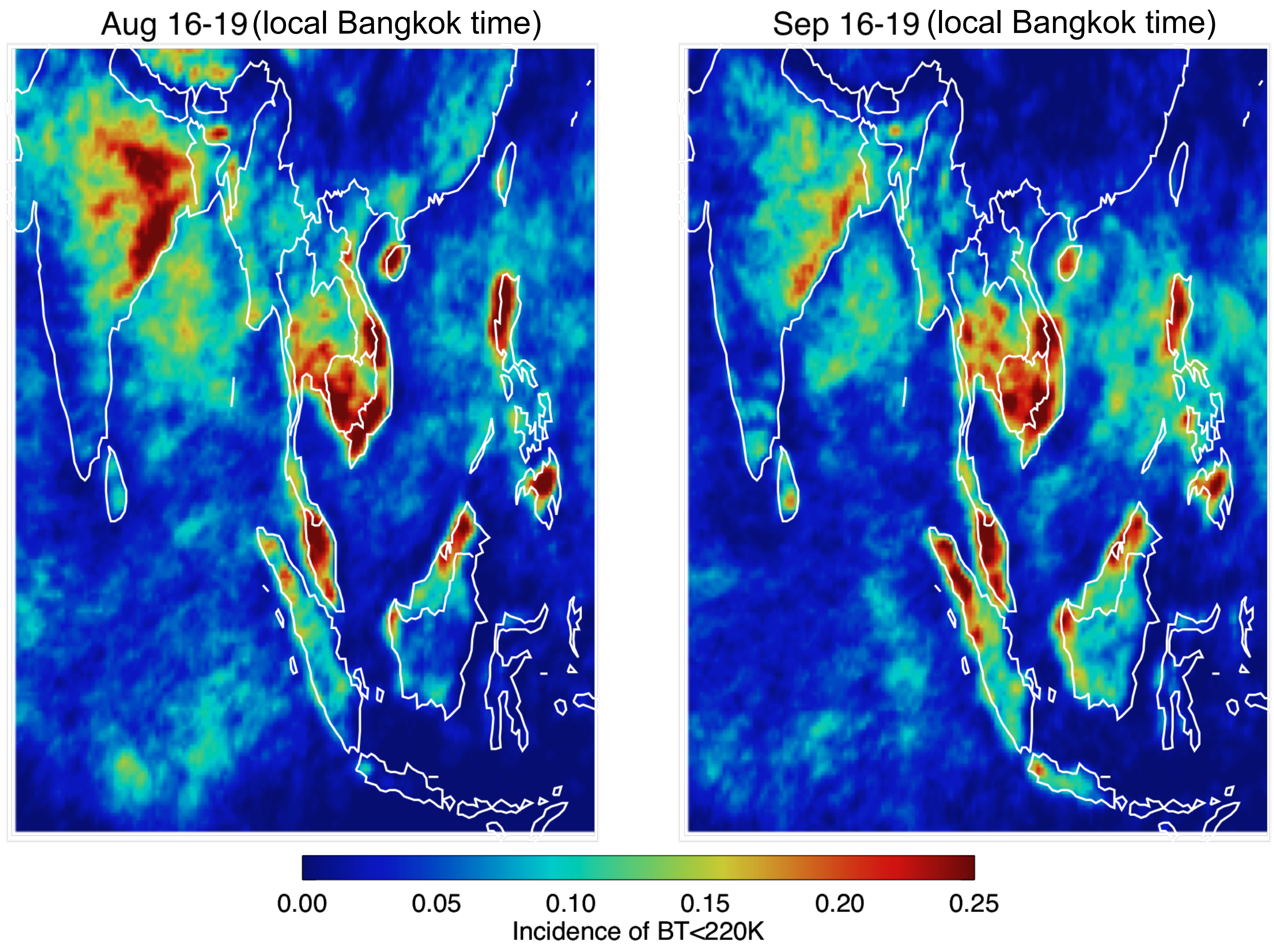
Lightning Climatology for August (flashes/mo in 25×25 km grid cells)



Lightning Climatology for September (flashes/mo in 25×25 km grid cells)



Diurnal Variations


Aug 16-19 (local Bangkok time)
Sep 16-19 (local Bangkok time)
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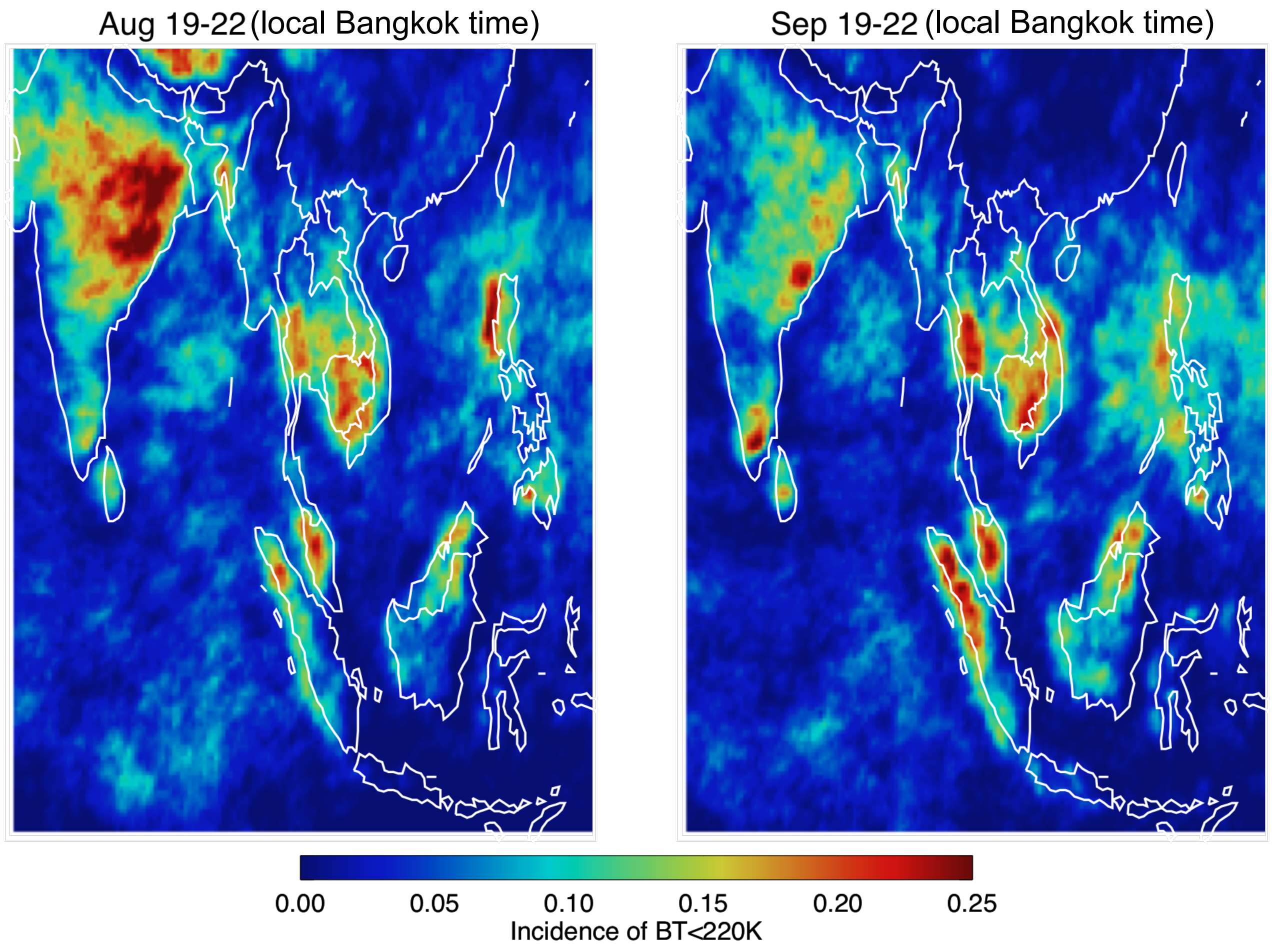
Incidence of BT<220K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Sep 19-22 (local Bangkok time)
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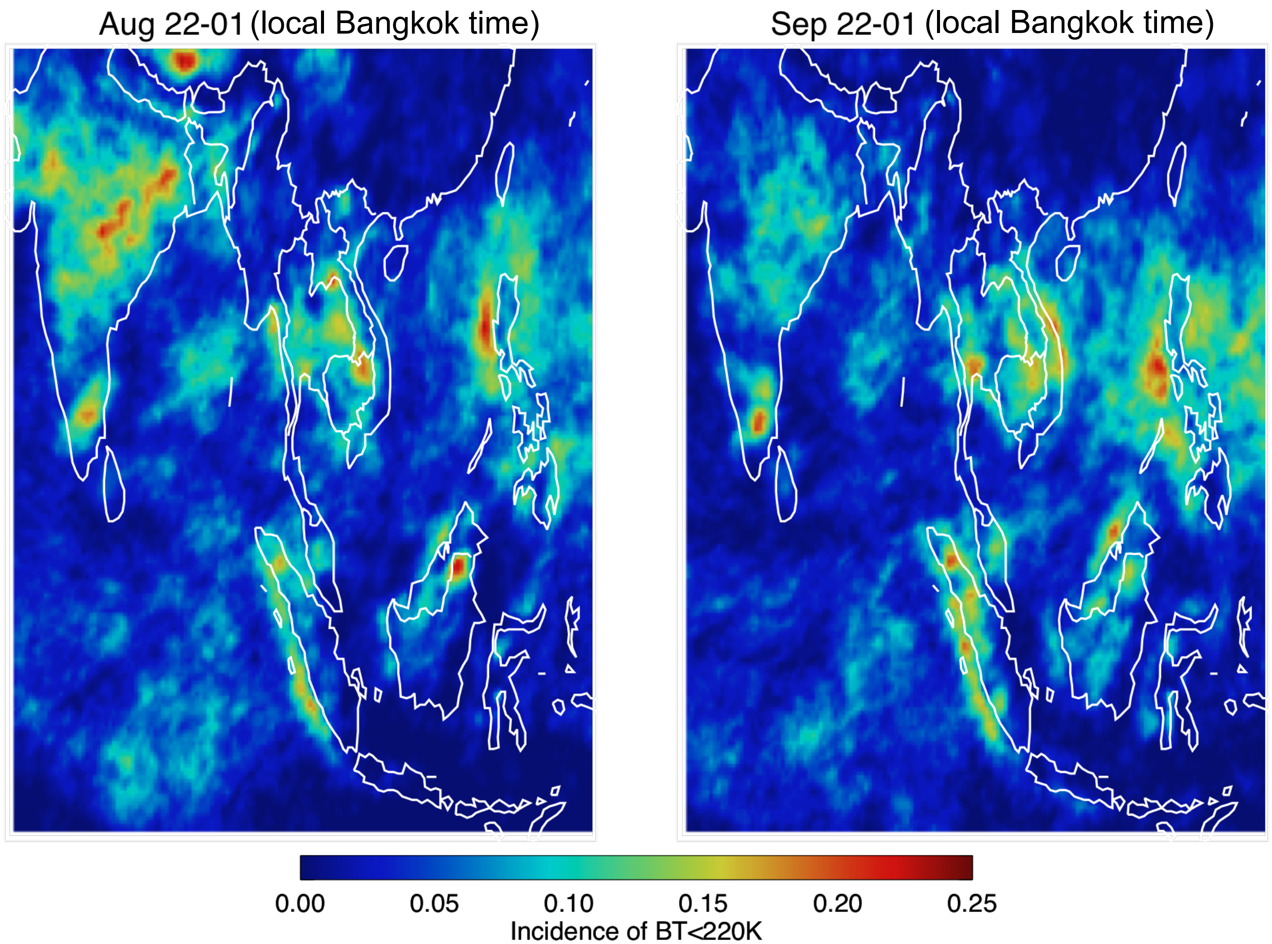
Incidence of BT<220K



Aug 22-01 (local Bangkok time)
Sep 22-01 (local Bangkok time)
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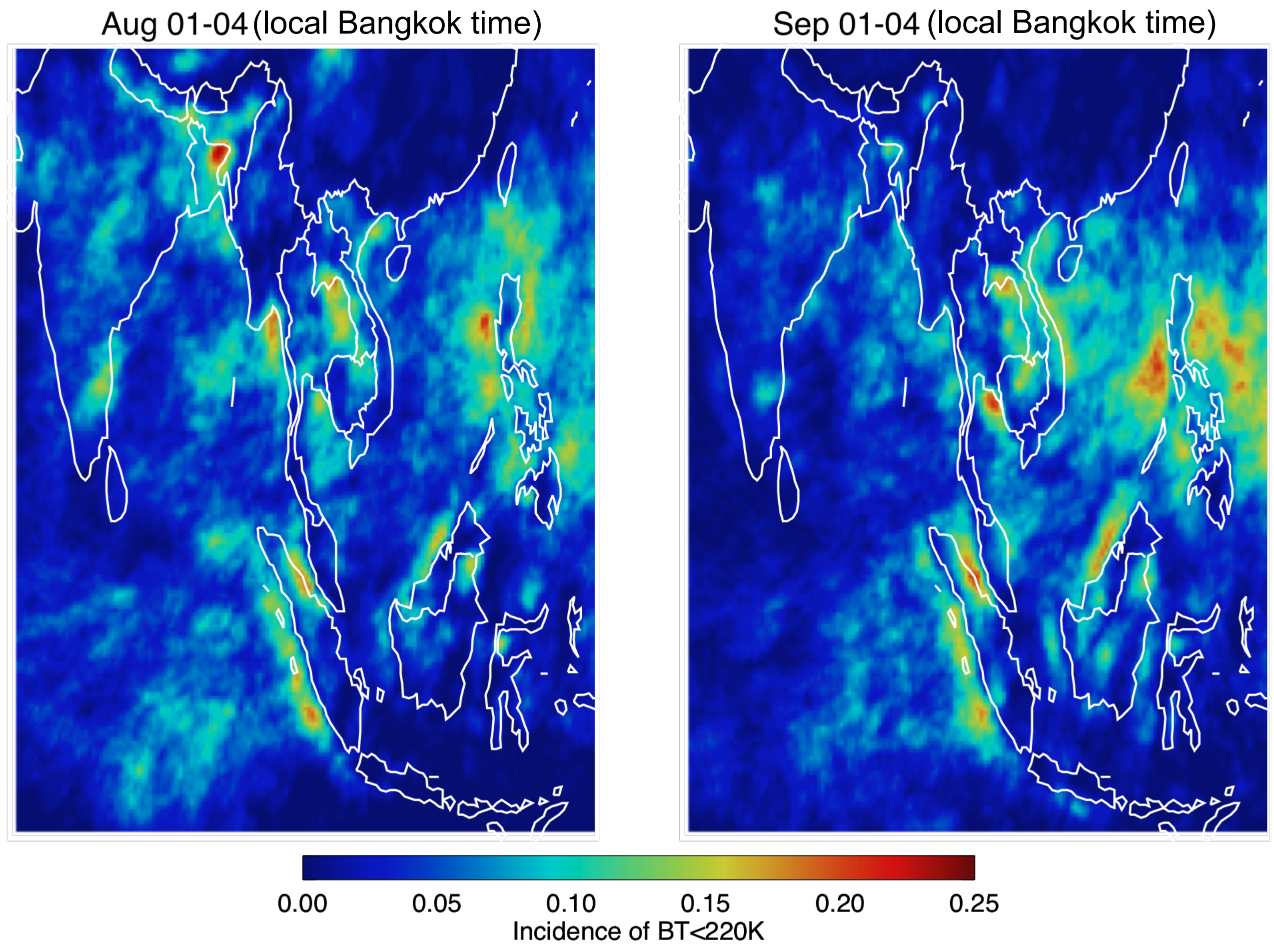
Incidence of BT<220K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Sep 01-04 (local Bangkok time)
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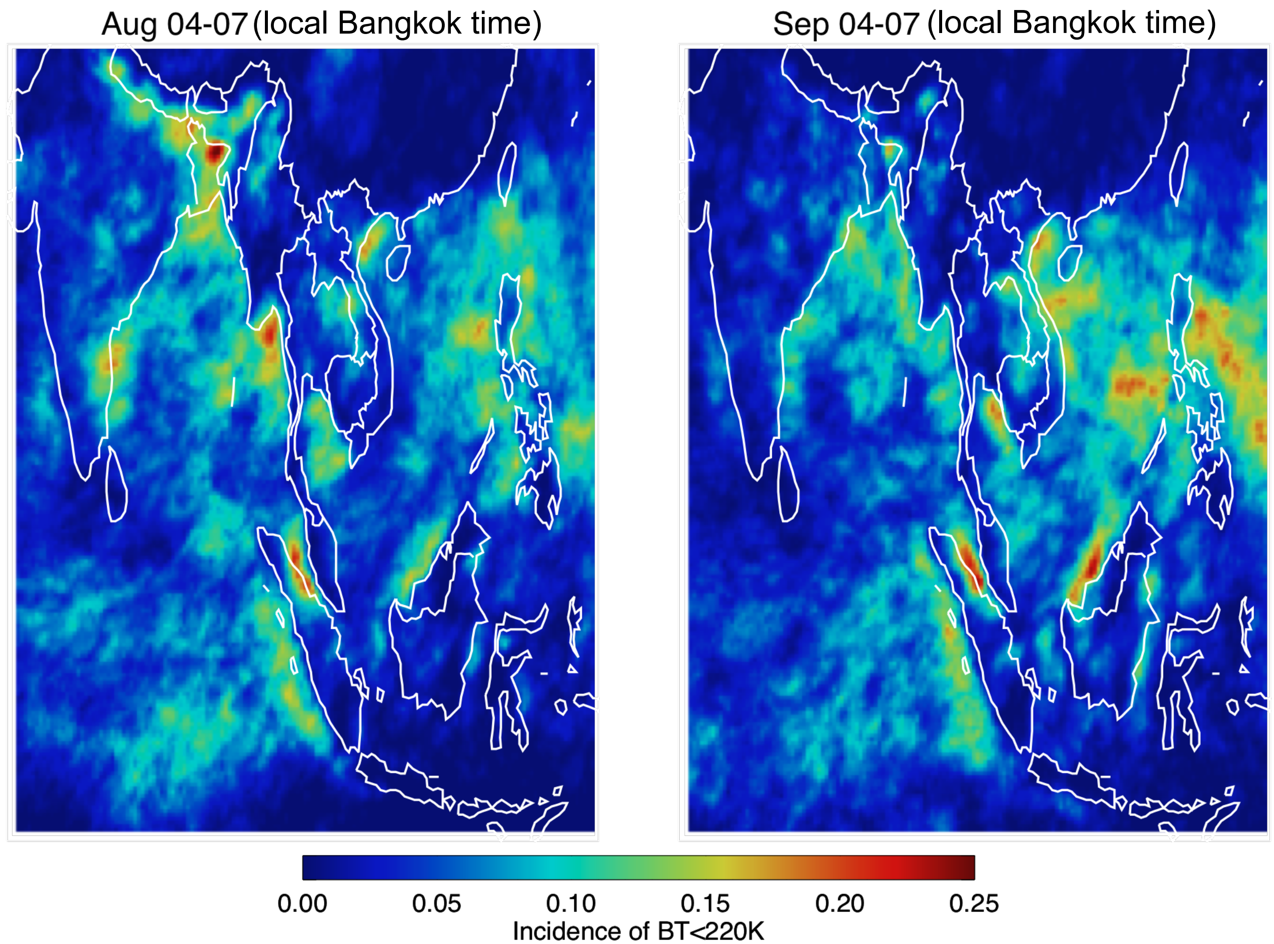
Incidence of BT<220K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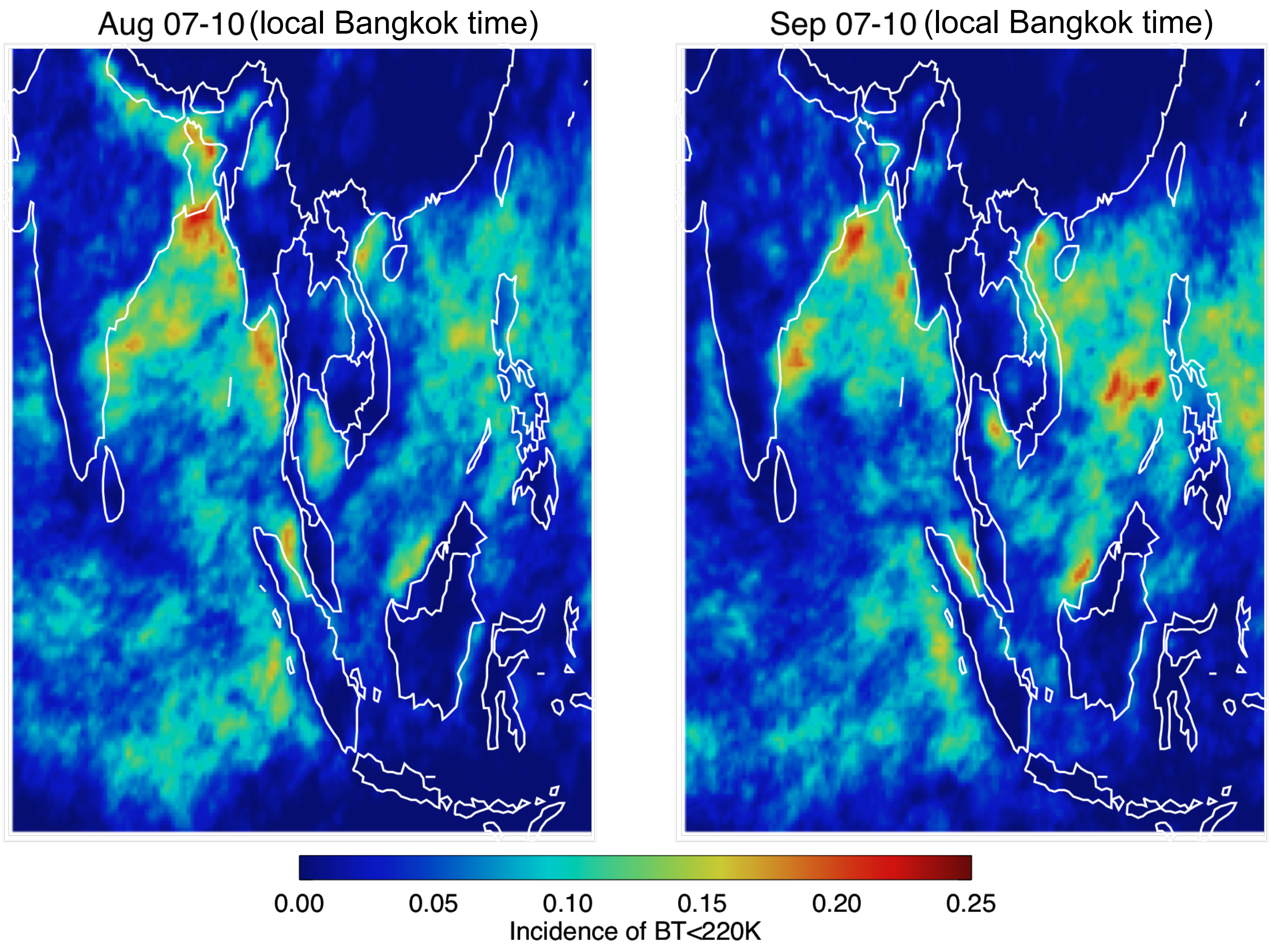
Incidence of BT<220K



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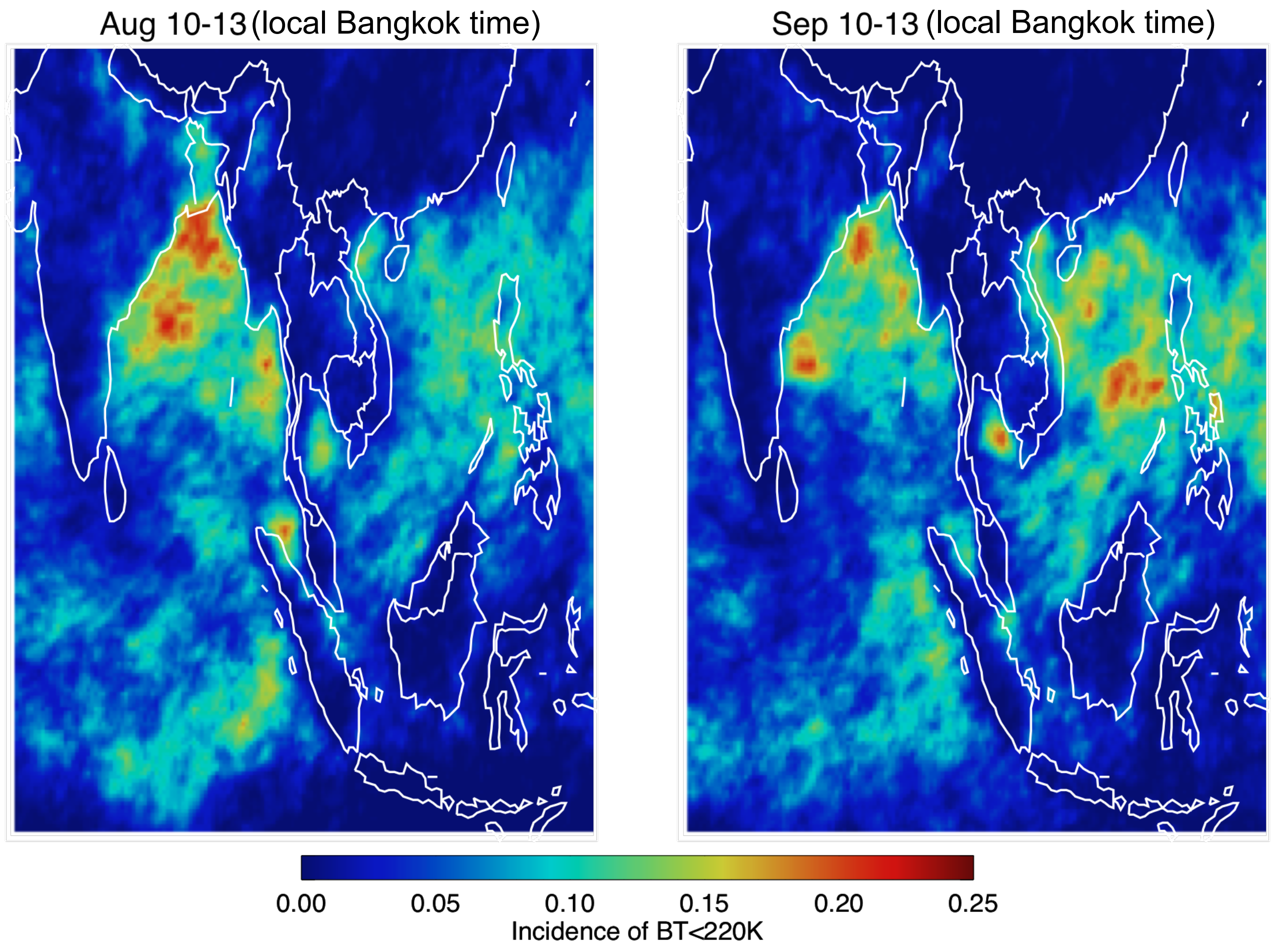
Incidence of BT<220K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Sep 10-13 (local Bangkok time)
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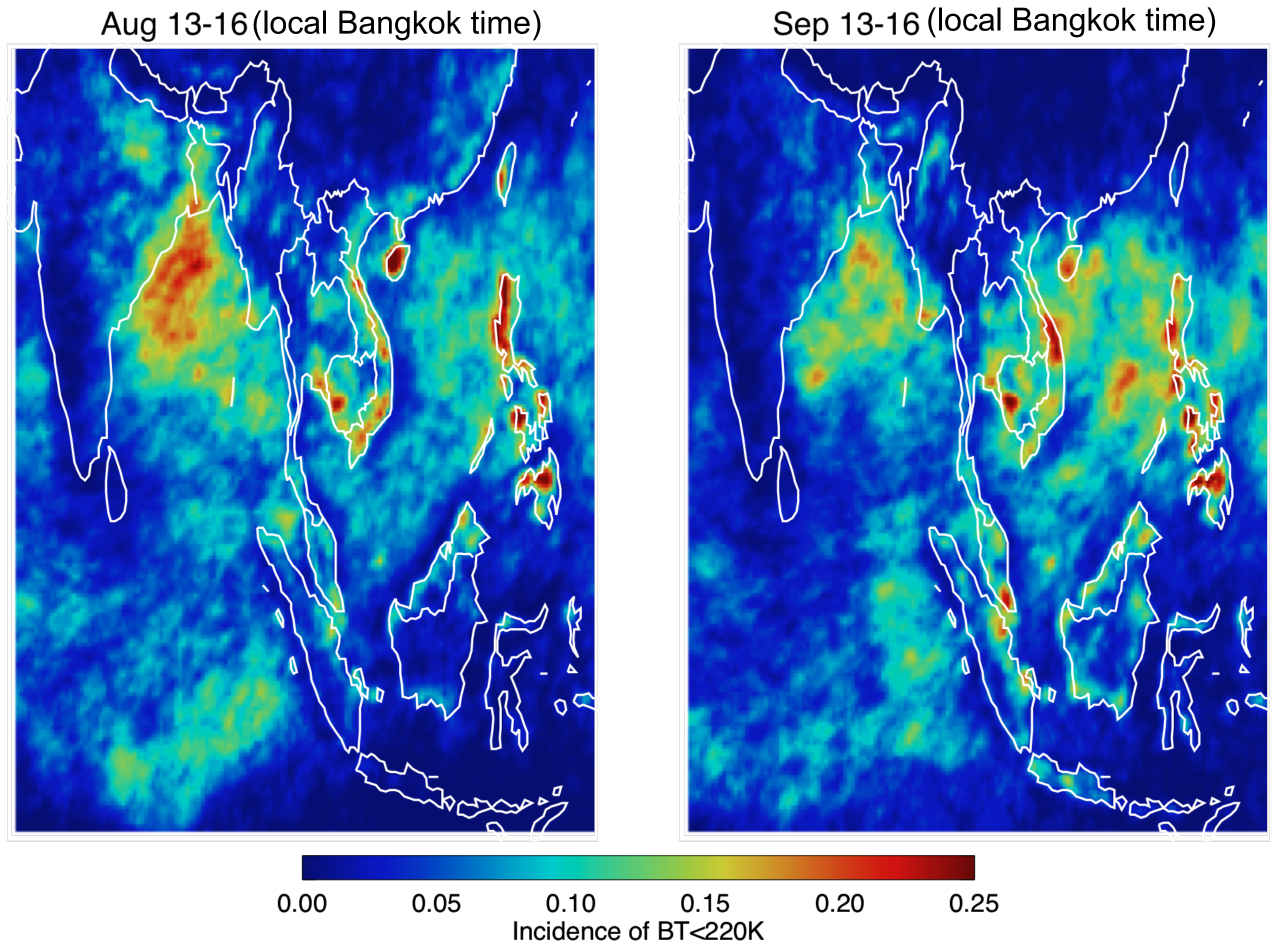
Incidence of BT<220K


Aug 13-16 (local Bangkok time)
Sep 13-16 (local Bangkok time)
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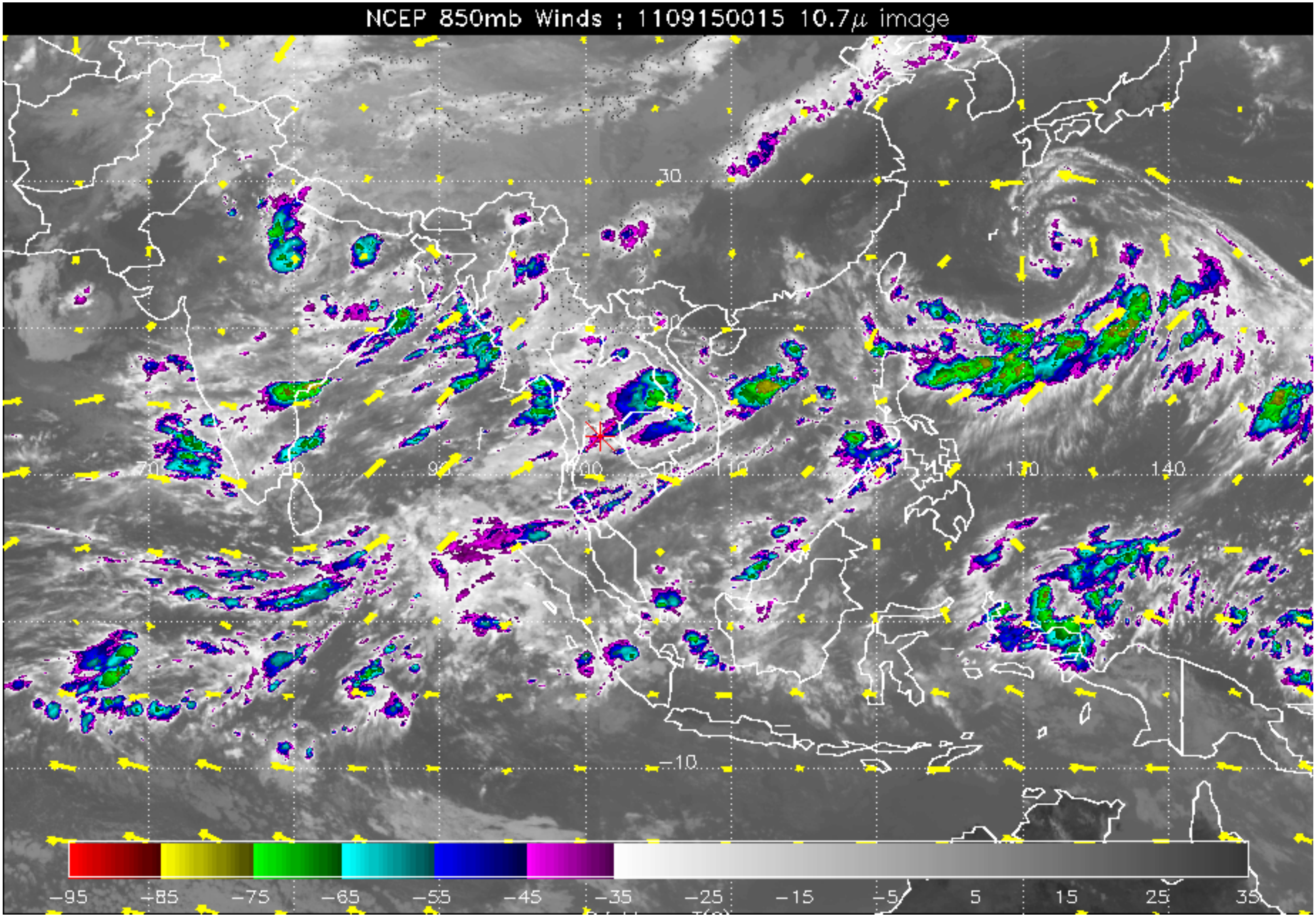
Incidence of BT<220K


NCEP 850mb Winds ; 1109150015 10.7μ image
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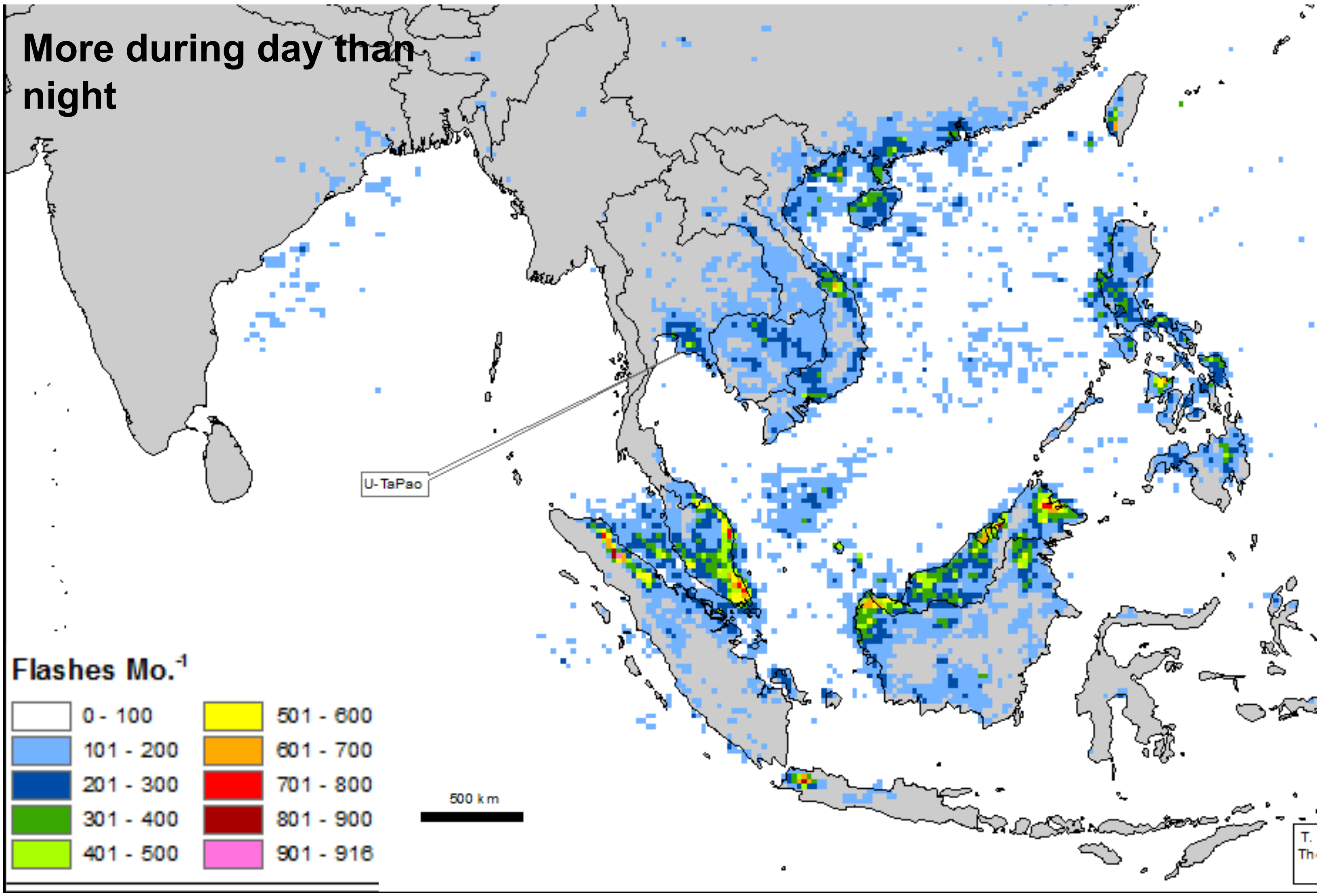
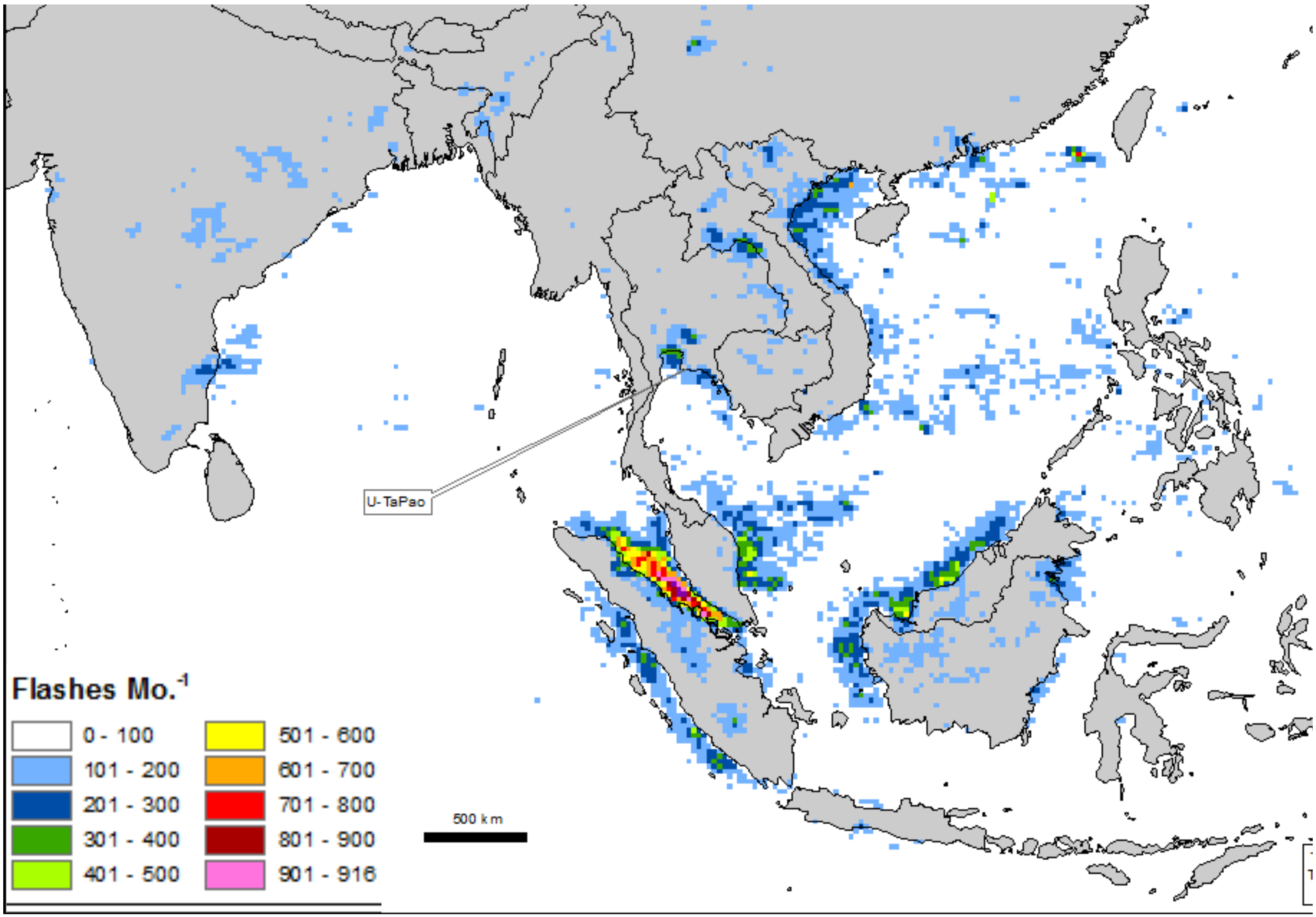
September Daytime

Much sea breeze and topographic influence

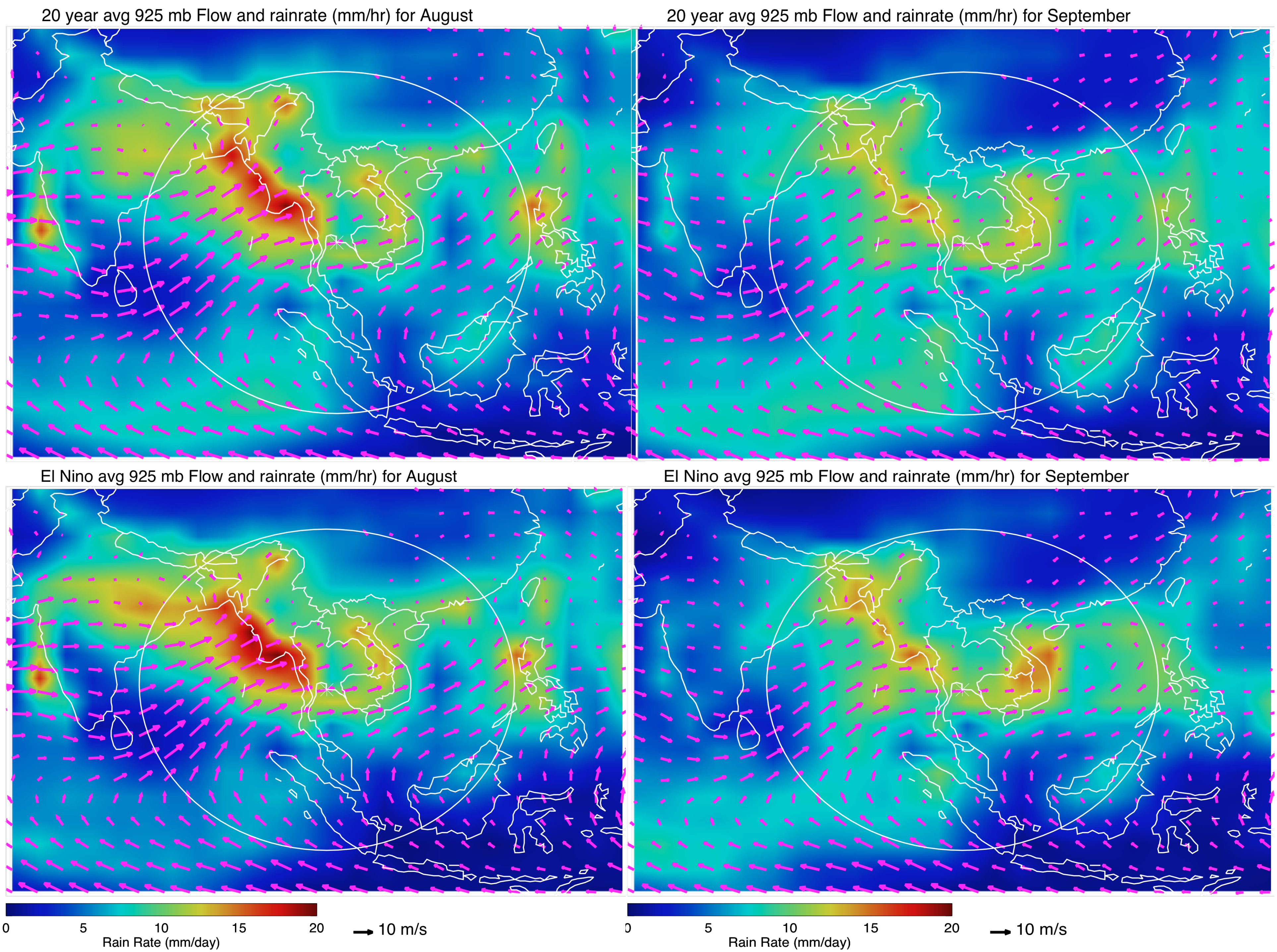


September Nighttime
Less Lightning and more Land Breeze Effect

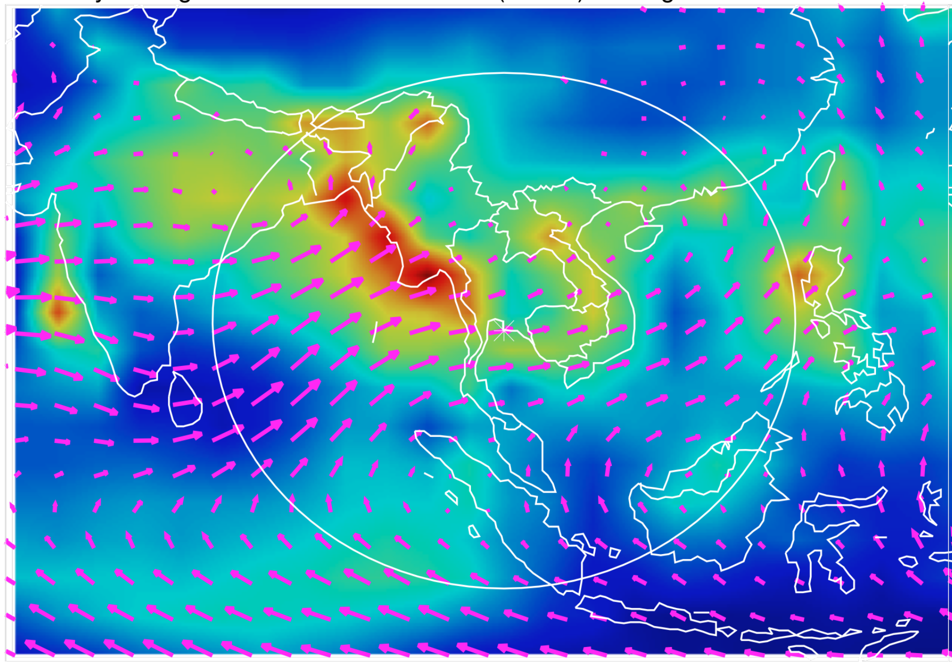


Interannual variations -- ENSO

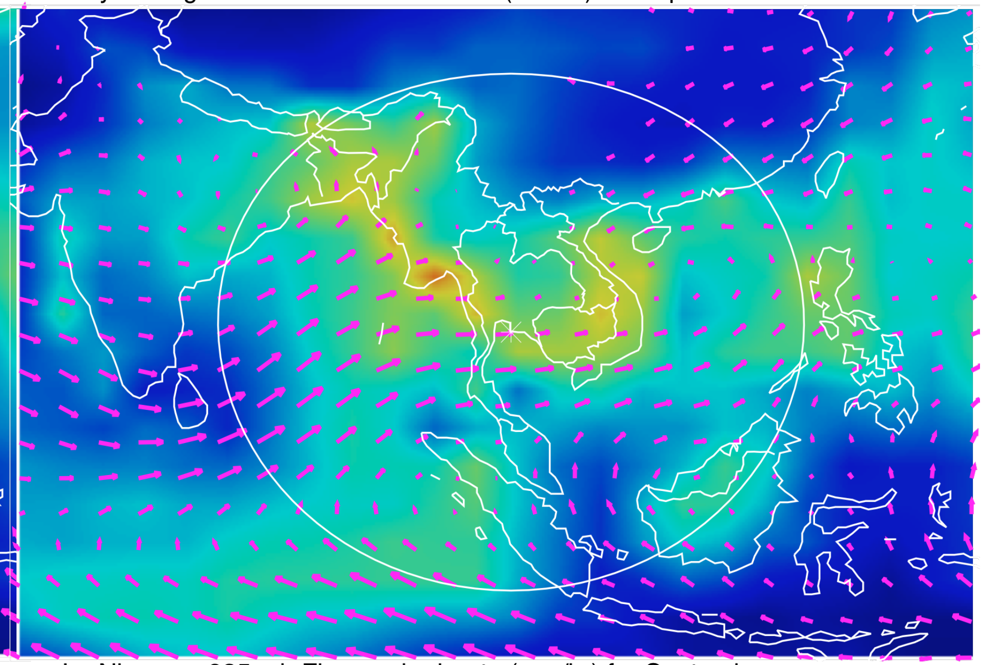
- Traditional El-Nino (eastern Pacific T enhancement) results in reduced rainfall in the Indian Ocean south of the equator and in Borneo and Malaya.
- Modoki (Dateline) El Nino in autumn does not have as substantial a negative precip anomaly as conventional el Nino (Larkin and Harrison)
- El Nino tends to raise tropopause (100mb) temperature minima over BoB-Indonesia region (difference between El Nino and La Nina is about a degree)
- 100mb anticyclone is more compact during La Nina years – impact on trajectories (later)
- Recent years – 2004, 2009 (Modoki El Ninos); 2006 ("regular"El Nino); 2007, 2010, 2011 (?) (La Nina); 2005, 2008 (neutral).


20 year avg 925 mb Flow and rainrate (mm/hr) for August
20 year avg 925 mb Flow and rainrate (mm/hr) for September
El Nino avg 925 mb Flow and rainrate (mm/hr) for August
El Nino avg 925 mb Flow and rainrate (mm/hr) for September
0 5 10 15 20
Rain Rate (mm/day)
10 m/s
0 5 10 15 20
Rain Rate (mm/day)
10 m/s

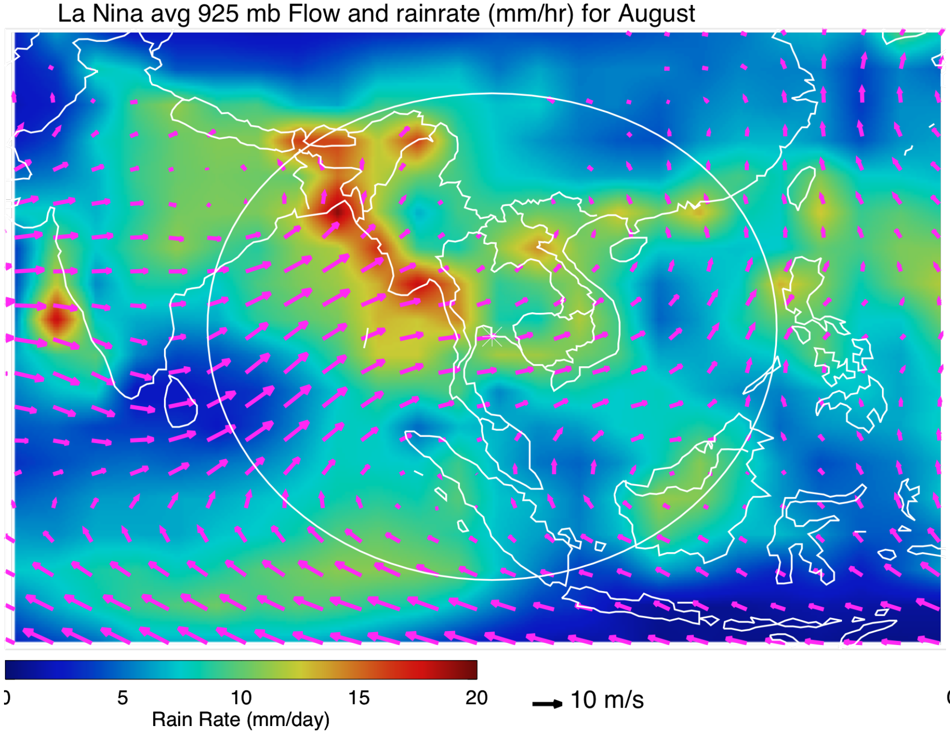
20 year avg 925 mb Flow and rainrate (mm/hr) for August



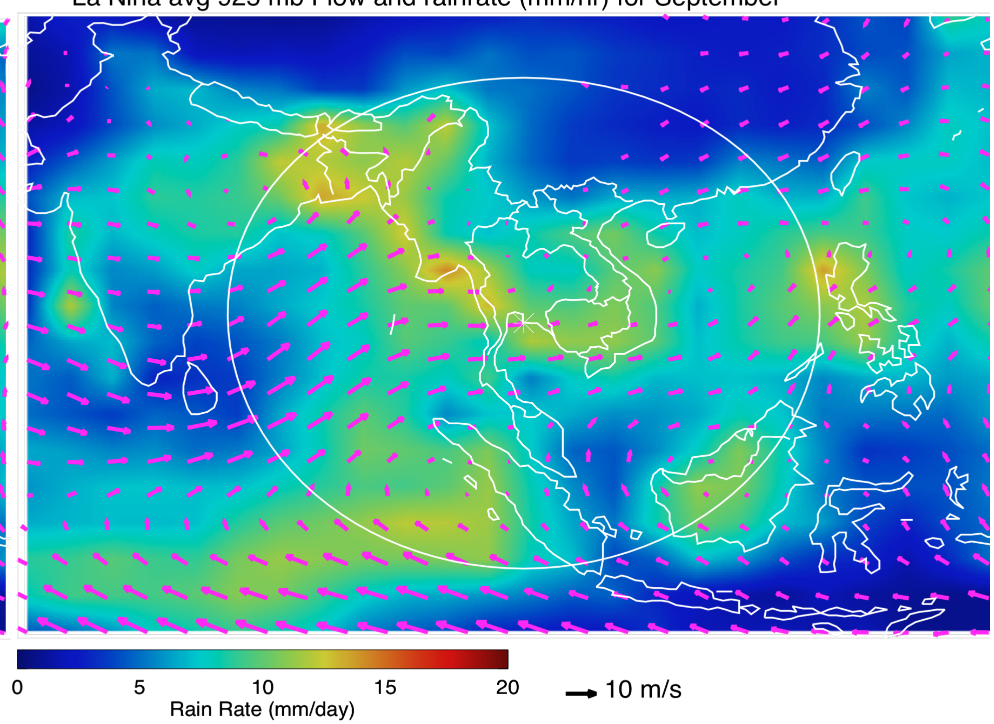
20 year avg 925 mb Flow and rainrate (mm/hr) for September



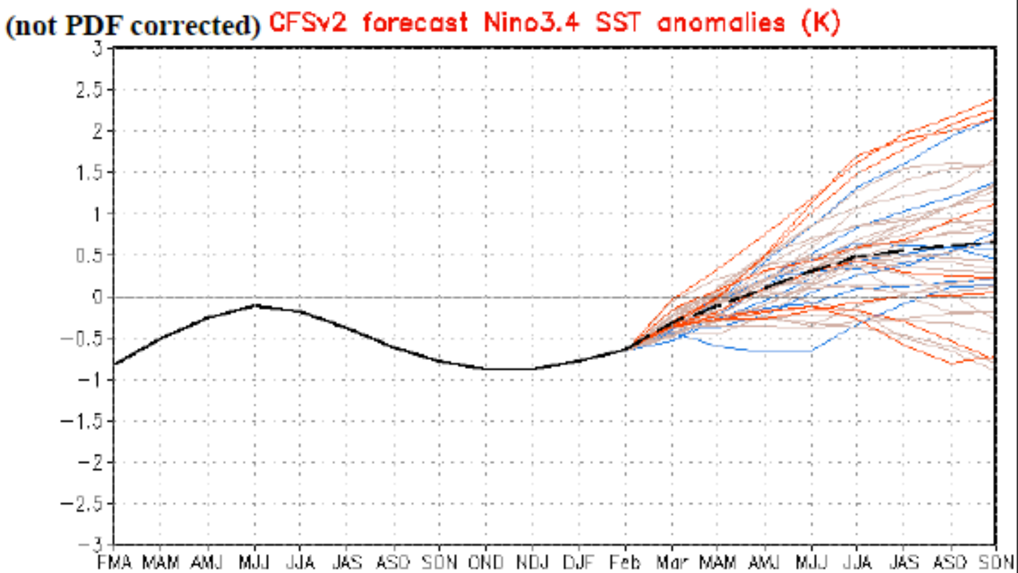
La Nina avg 925 mb Flow and rainrate (mm/hr) for August

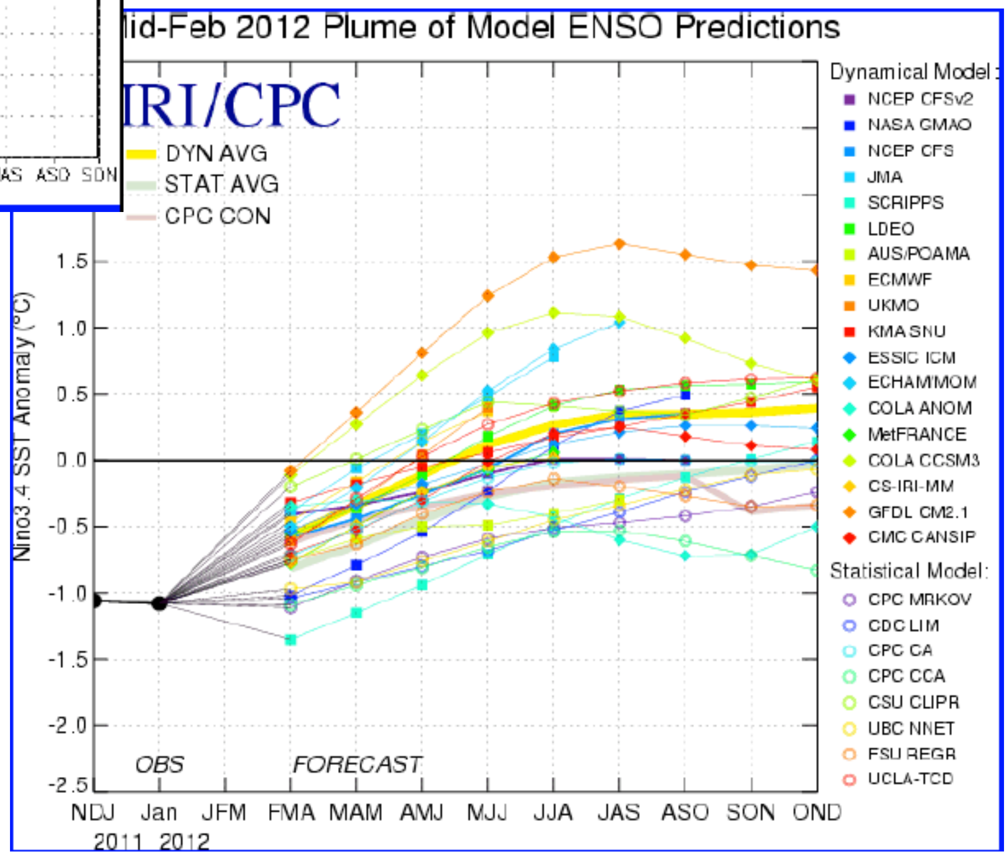


La Nina avg 925 mb Flow and rainrate (mm/hr) for September



The CFS.v2 ensemble mean (black dashed line) predicts ENSO-neutral conditions beginning in March-May 2012.

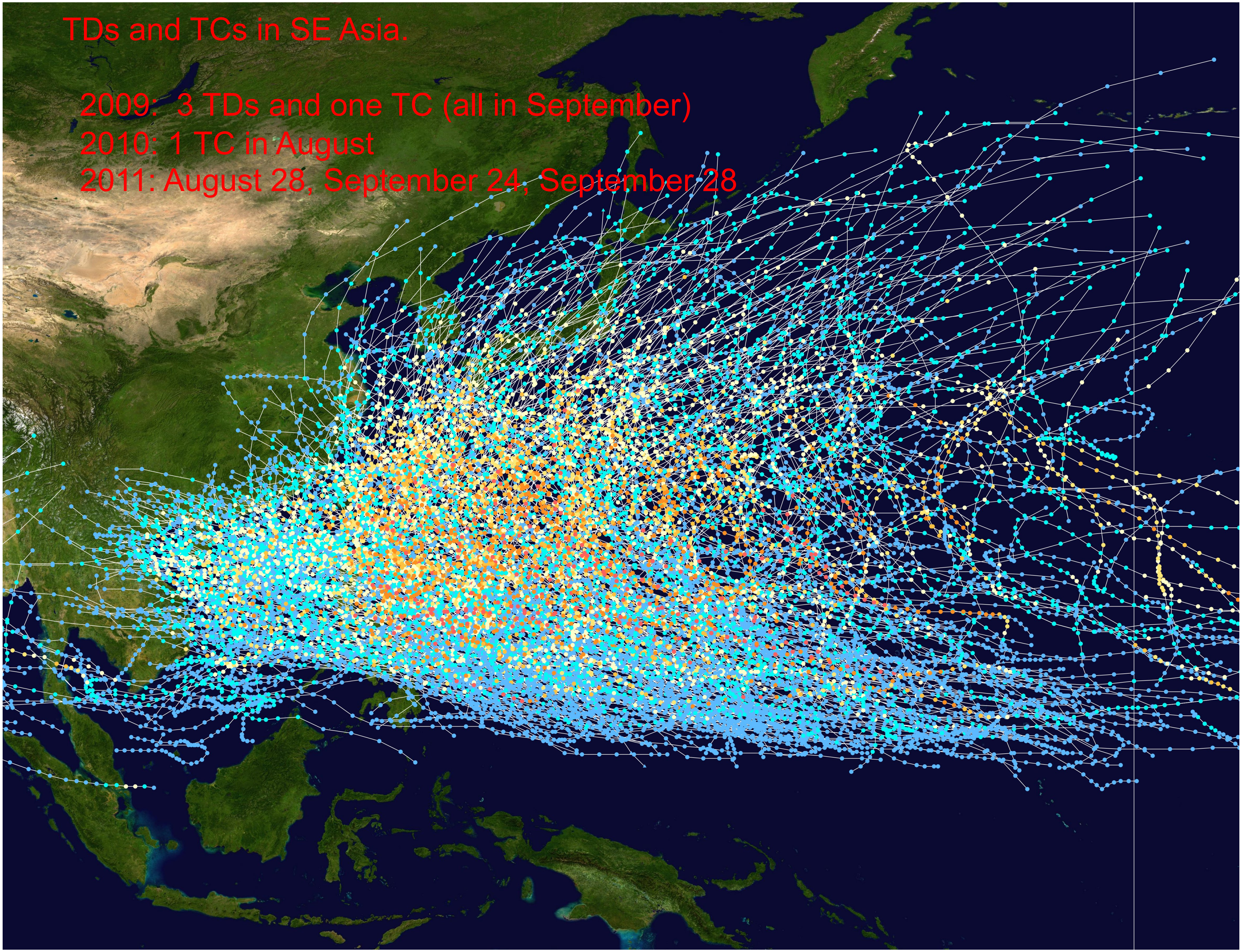




Models (NCEP Climate forecast system (above), multi-models (right) forecast neutral to weak El Nino conditions by the time of the experiment. Among recent years, 2005, 2006, or 2008 may have similar ENSO status as what we might expect this Aug-Sep.

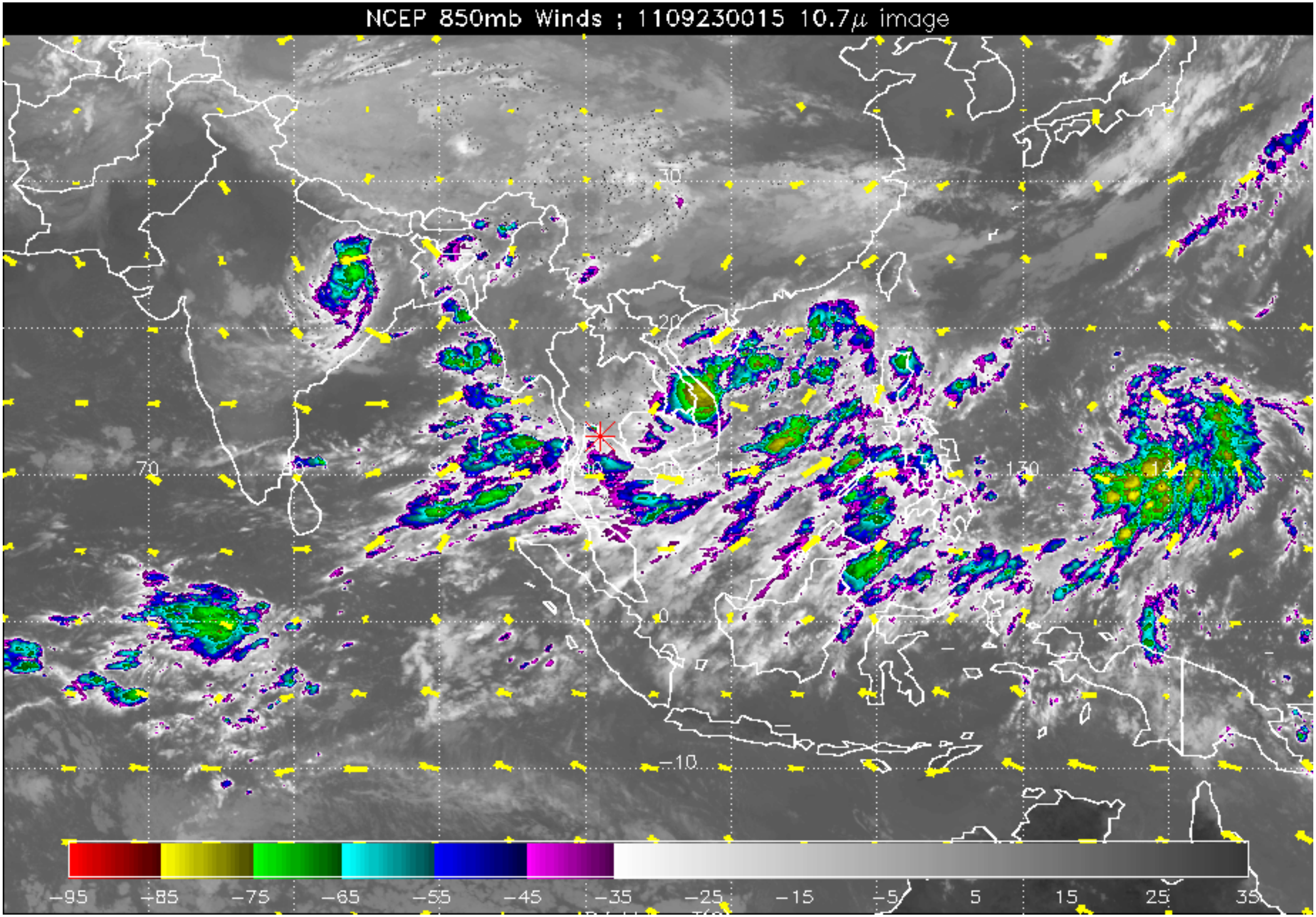
Waves, TCs, Intra-Seasonal variations

- Tropical cyclones, easterly waves
- Intra-Seasonal Oscillation (Madden-Julian Oscillation)
- Convectively Coupled Waves


TDs and TCs in SE Asia.
2009: 3 TDs and one TC (all in September)
2010: 1 TC in August
2011: August 28, September 24, September 28

Tropical Cyclones

- Paths show some reaching SEAC4RS area
- Maximum incidence of TC in Philippines in September
- All 3 years of satellite loops (2009-2011) show at least one TC entering Indochina.
- ENSO effect – during neutral and El Nino years fewer TC impact China and Indochina.
- During La Nina, TC landfalls in Indochina and China increase (Wu et al, 2003). But 2009 El Nino year had more Indochina TCs than La Nina 2010.


NCEP 850mb Winds ; 1109230015 10.7μ image
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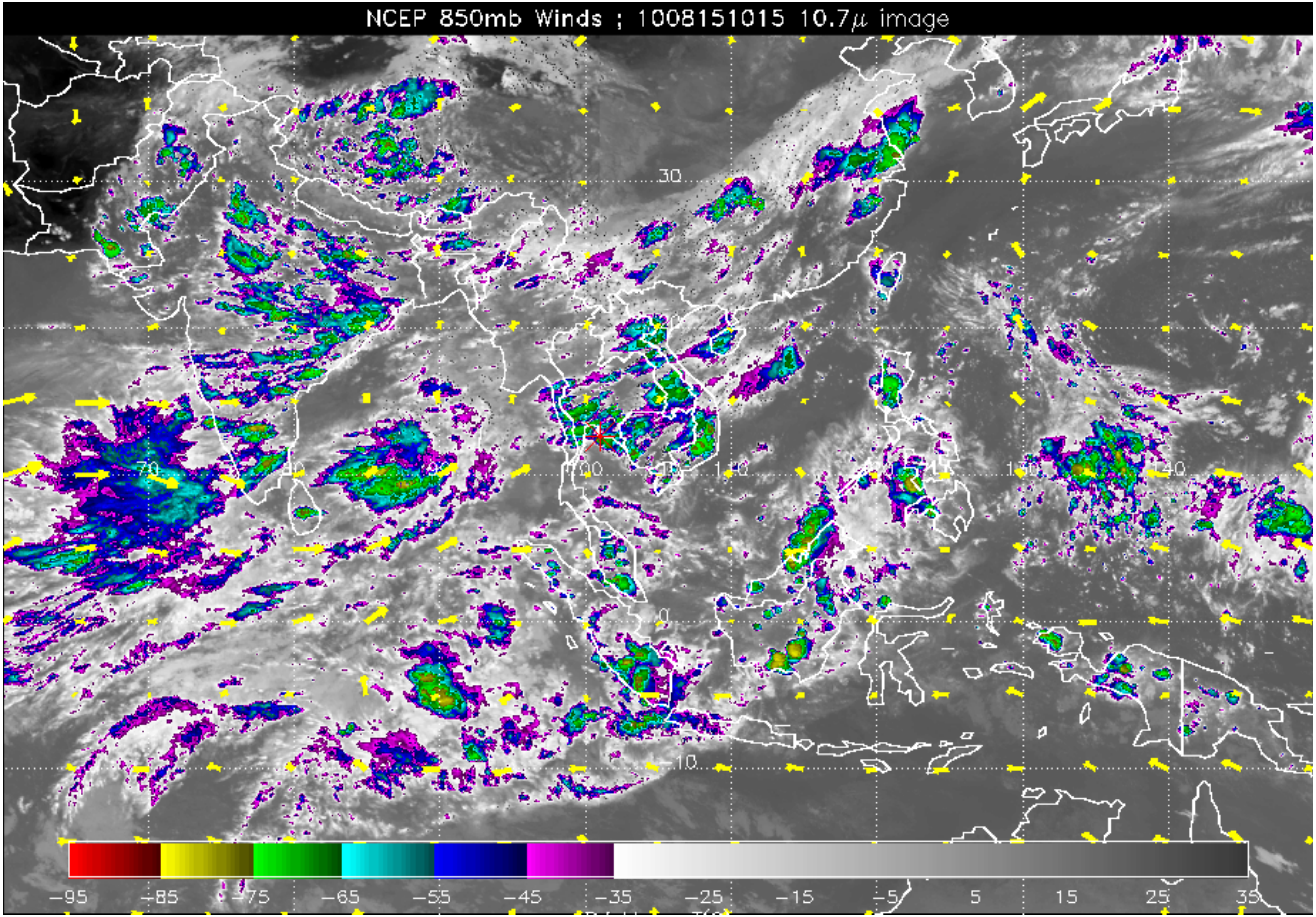
35

Easterly Waves



NCEP 850mb Winds ; 1008151015 10.7μ image
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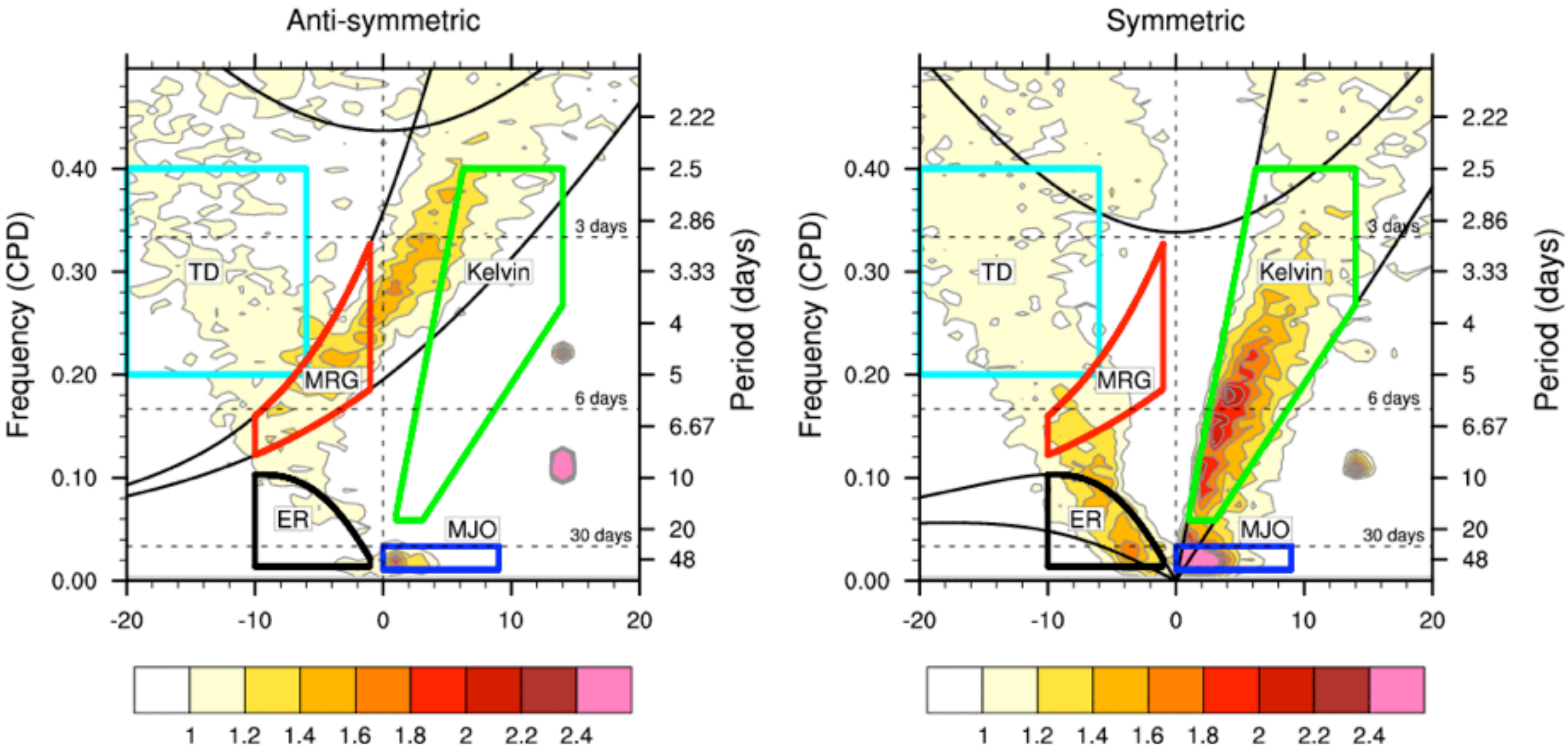
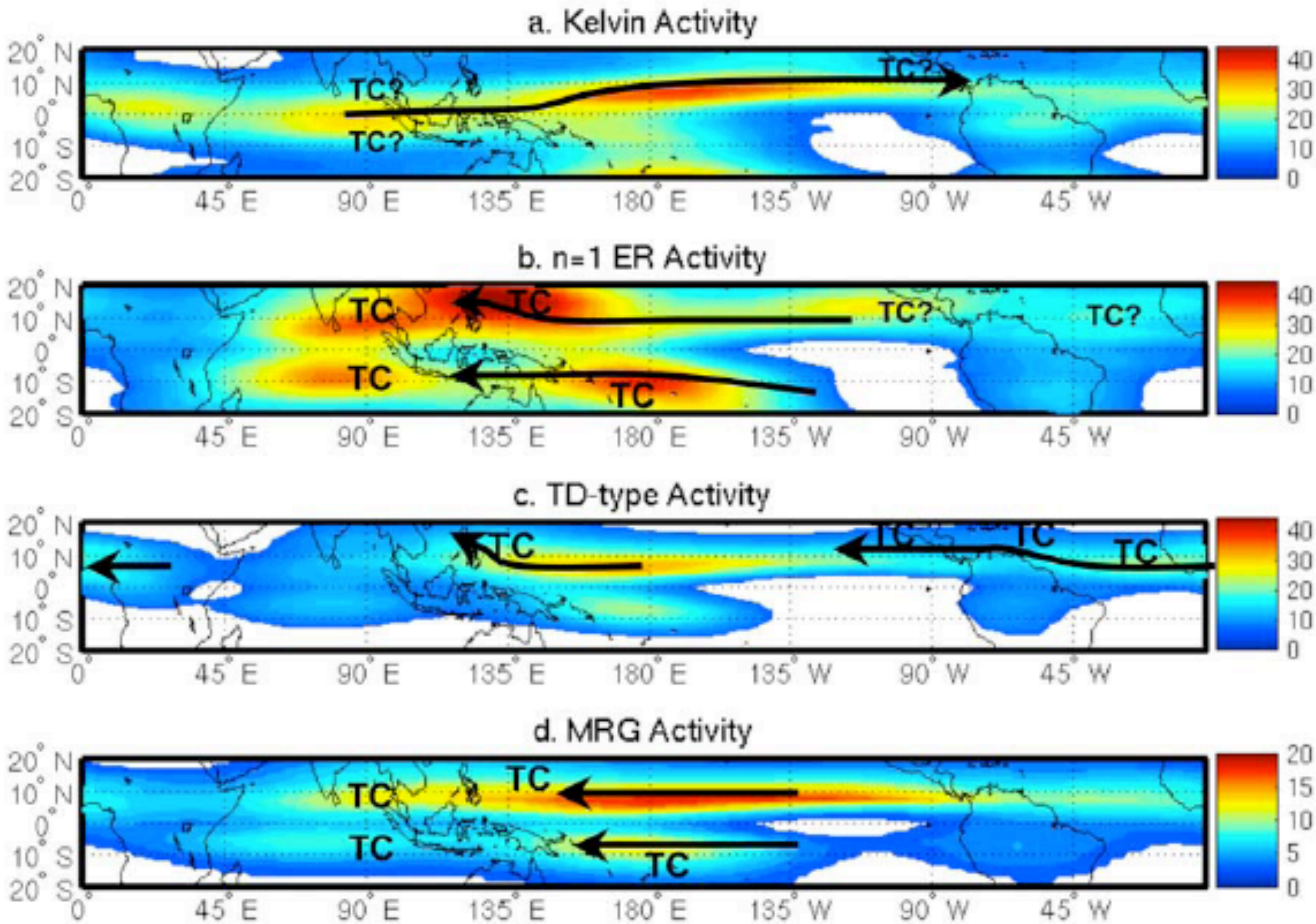
OLR (IR cloudiness) spectrum (-20S-20N) – from Carl Schreck, CICS

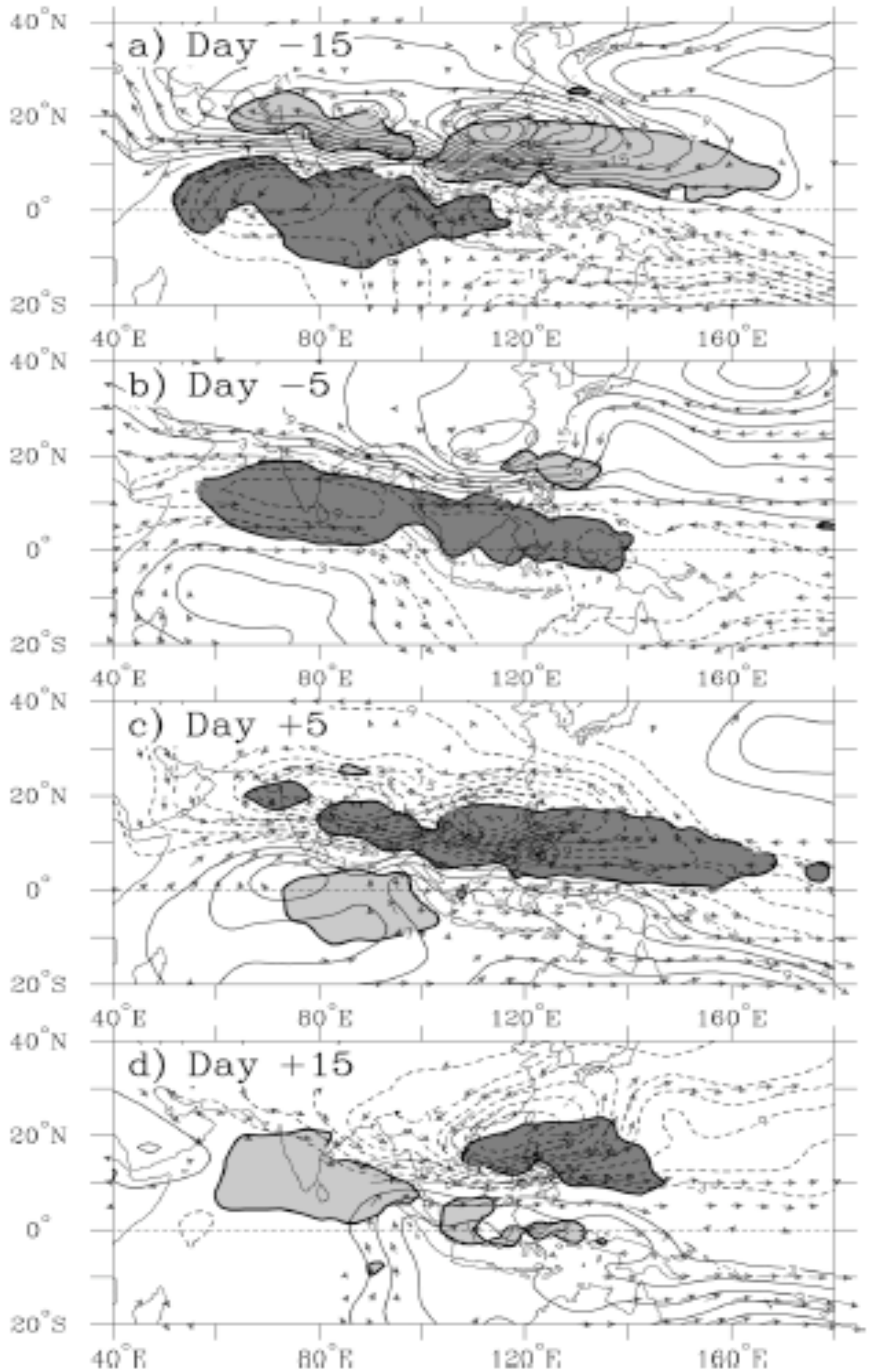


This analysis originally done by Wheeler and Kiladis, 1999



Easterly waves very similar to MRG in structure

From Kiladis et al (2009)

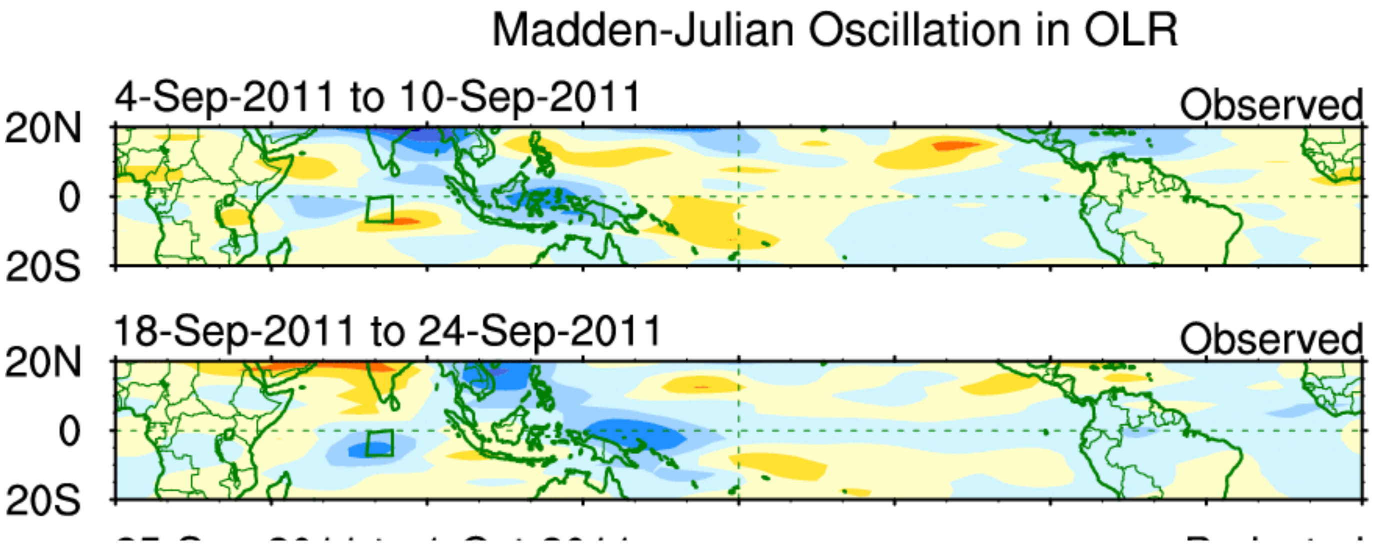


Intra-Seasonal Oscillation, Or Madden Julian Oscillation

"Classic" MJO (strongest in boreal winter) propagates eastward at 5 meters per second and is quasi-symmetric about the Equator. In boreal summer (Jun-Sep), peak variance is north of the equator (10N). MJO propagates northeastward – period of 30-60 days.

This pattern comes from EOF analysis of relevant MJO periods. Actual cloudiness pattern, even for the MJO itself, will vary. (All the other waves will contribute as well.)

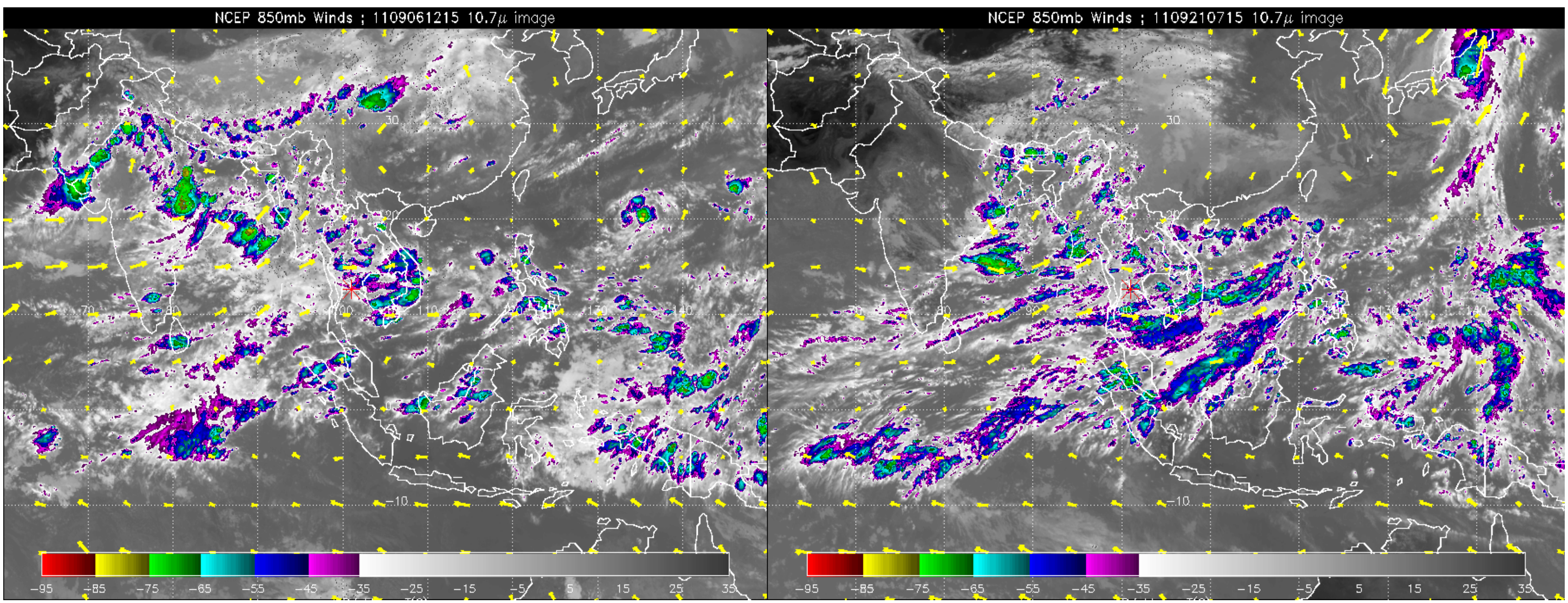
From Straub and Kiladis (2003)



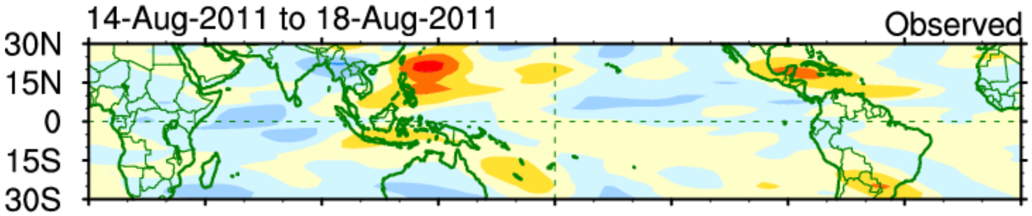
MJO dominates large scale pattern here – gradual movement to the northeast.

September 6

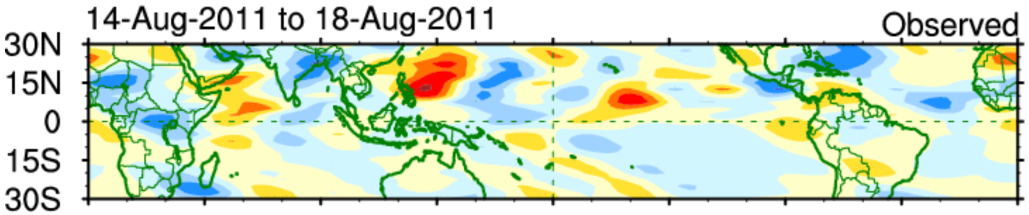
September 21



ISO/MJO amplitude comparable to or smaller than Equatorial Rossby Wave (also known As the quasi-biweekly oscillation)

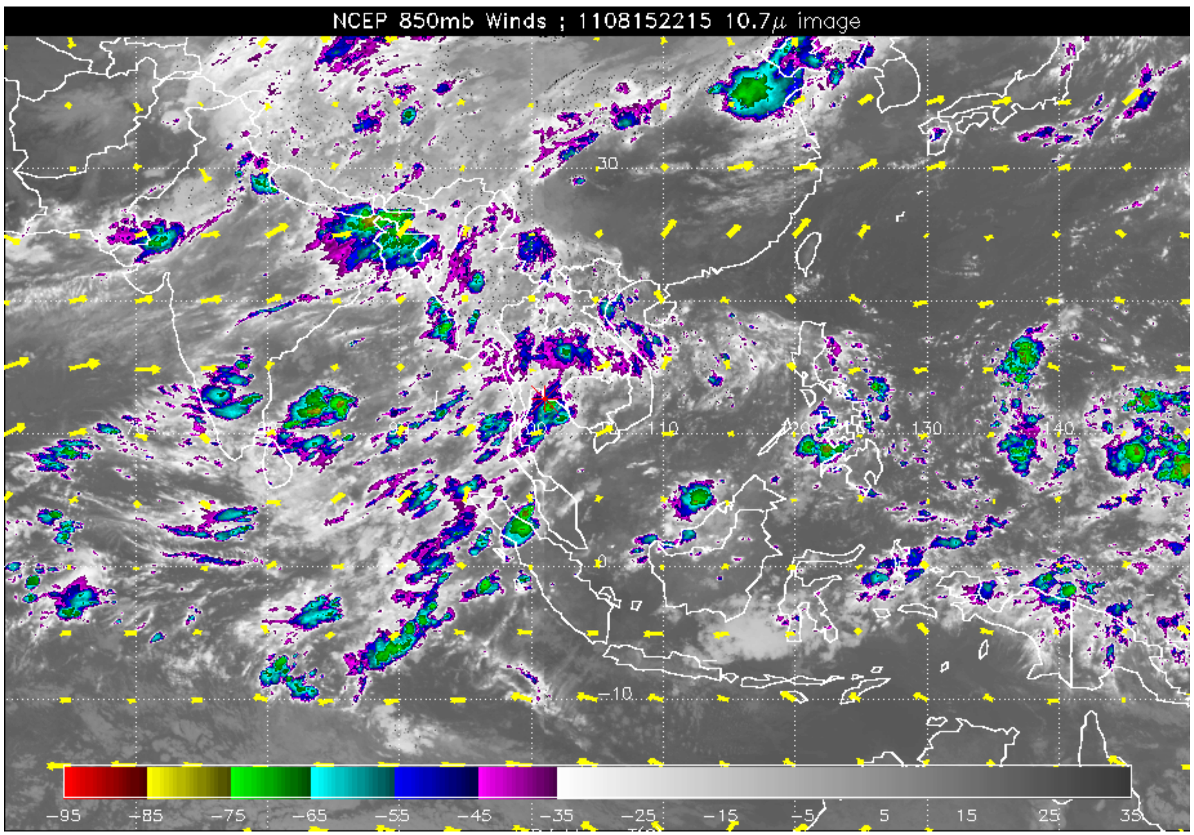


ISO/MJO OLR anomaly



ER OLR anomaly

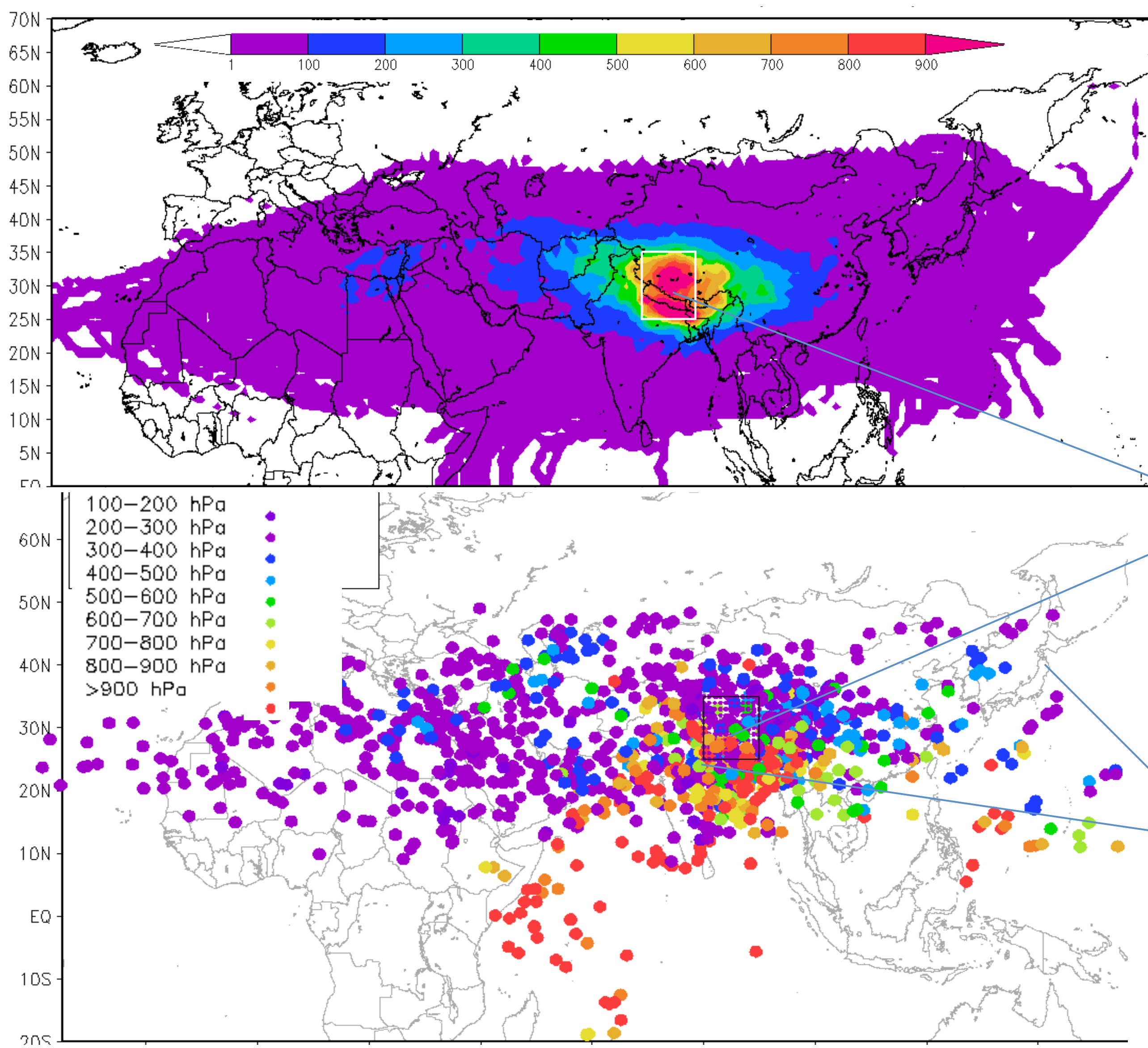
From Carl Schreck, CISC website



Air Origins – Trajectory Climatology at 100mb for August and September

Origins of Air at 100mb – Trajectory Climatology

Five Years of Augusts
10 Day Back Trajectories Arriving at 100 mb

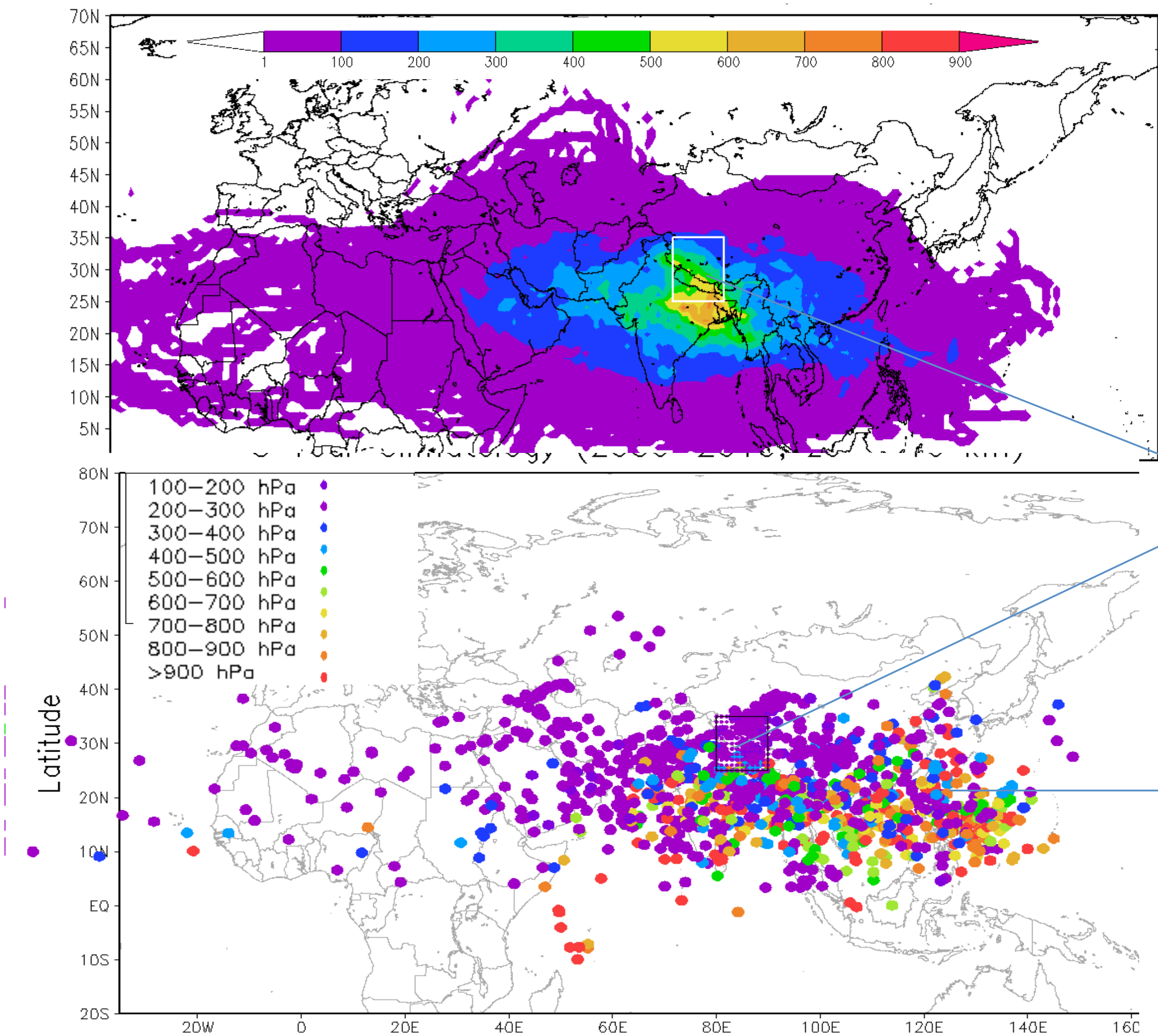


Paths:
Numbers of trajectories
Passing over grid boxes

The "box"

Pressures 10 days prior to arriving in the box
Lower origins in convective areas

Five Years of Septembers
10 Day Back Trajectories Arriving at 100 mb

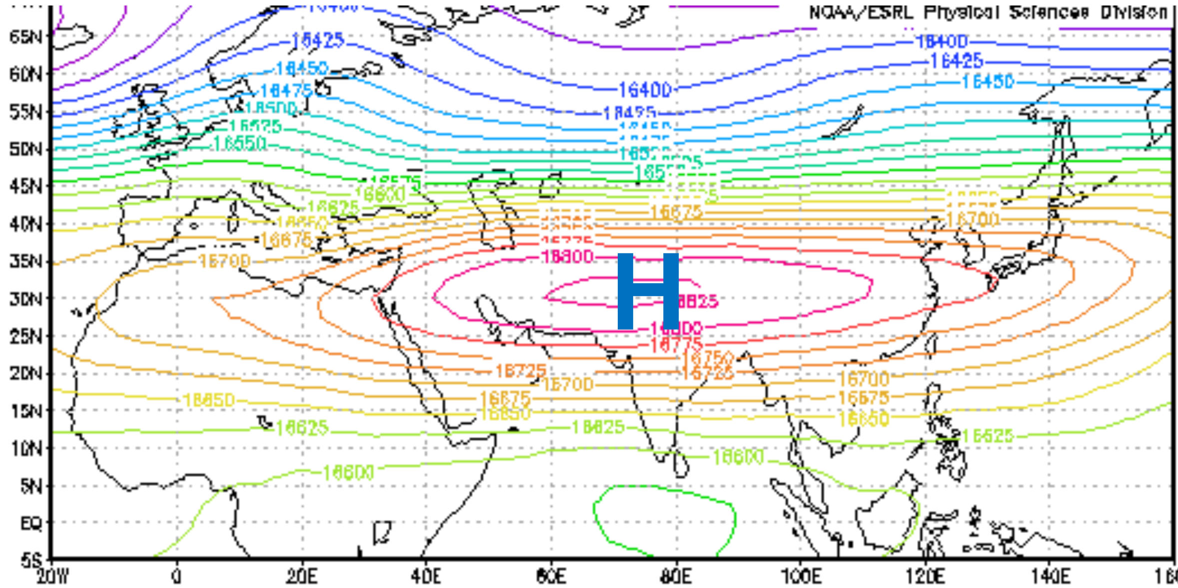


Paths:
Numbers of trajectories passing over grid boxes

The "box"

Pressures 10 days prior to arriving in the box
Lower starting altitudes in convective areas

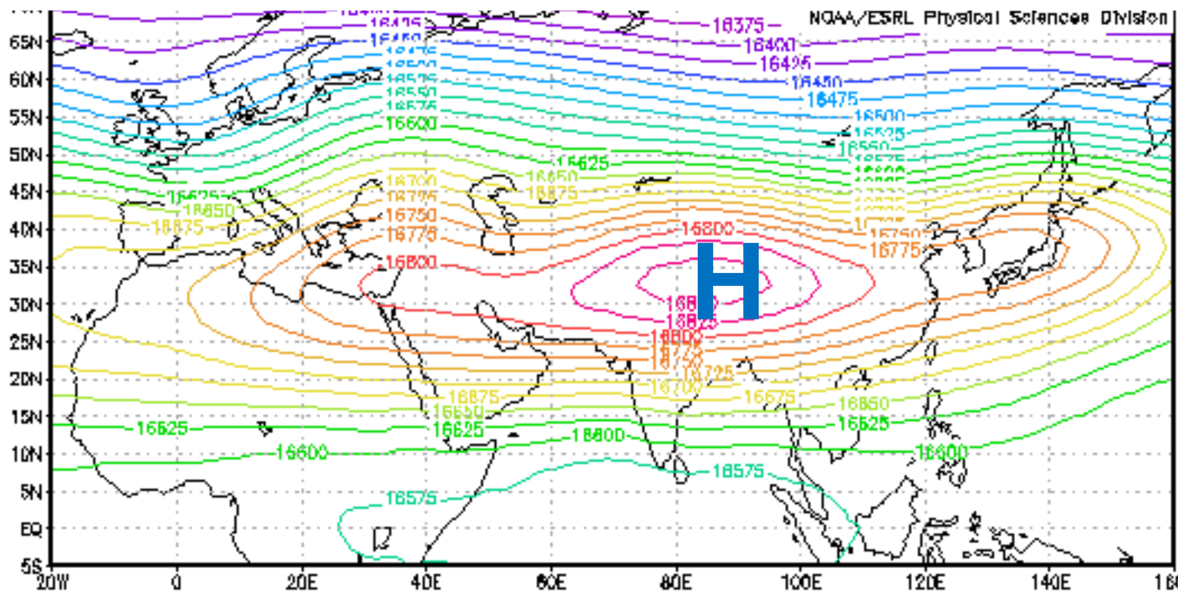
Mean Heights at 100 mb



August 2009

Elongated High

El Nino

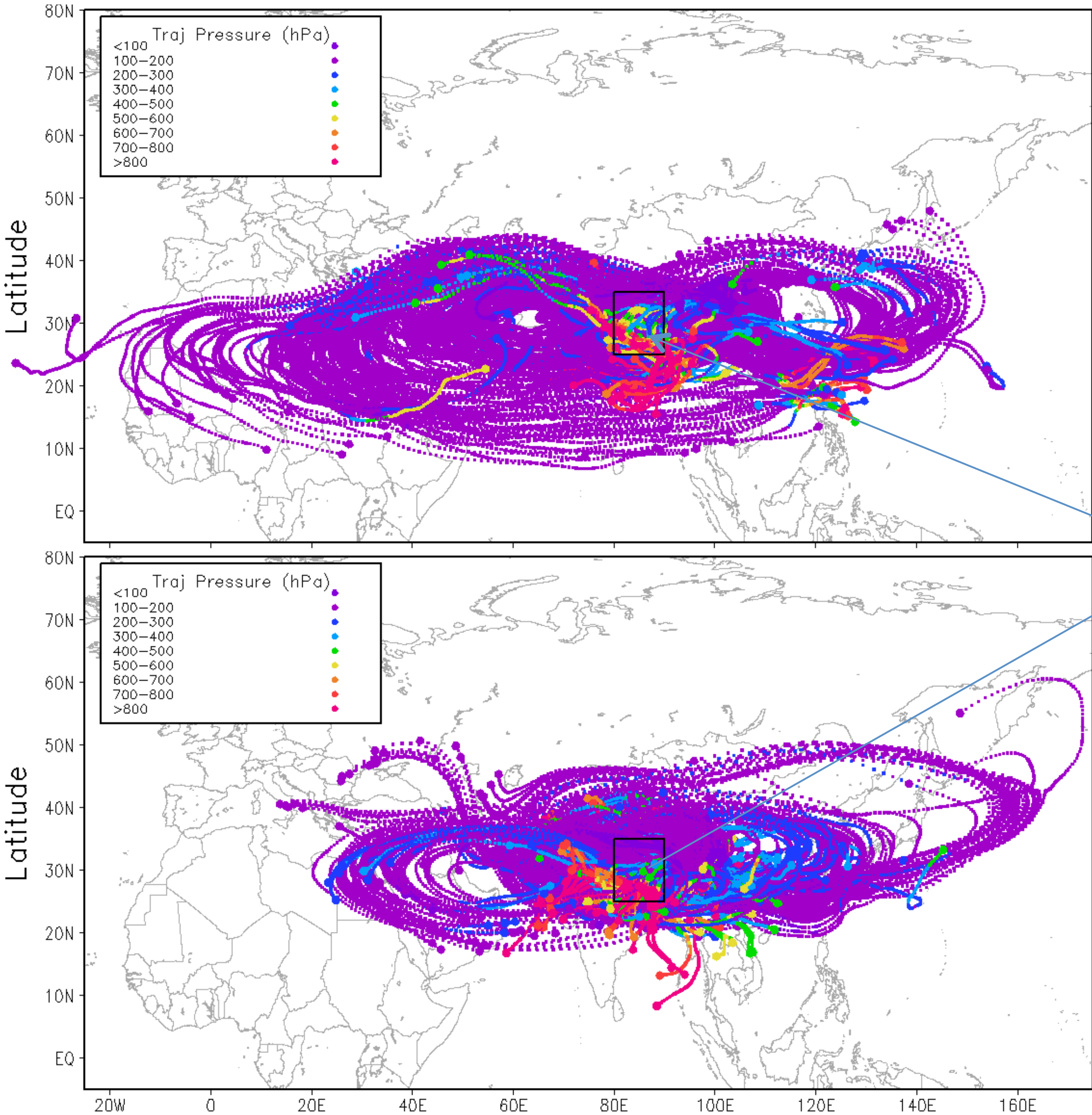


August 2010

Less Elongated

La Nina

10 day Back Trajectories from



August 2009
Broad path areas

Backwards from the box

August 2010
More confined paths

Utapao Weather Conditions

- Examine Diurnal variation
- Compare to San Jose during TC4

Rainfall (inches)

	July	August	Sep	Oct
San Jose	8.3	9.5	12.0	11.8
Sattahipp	3.7	4.2	8.9	11.0

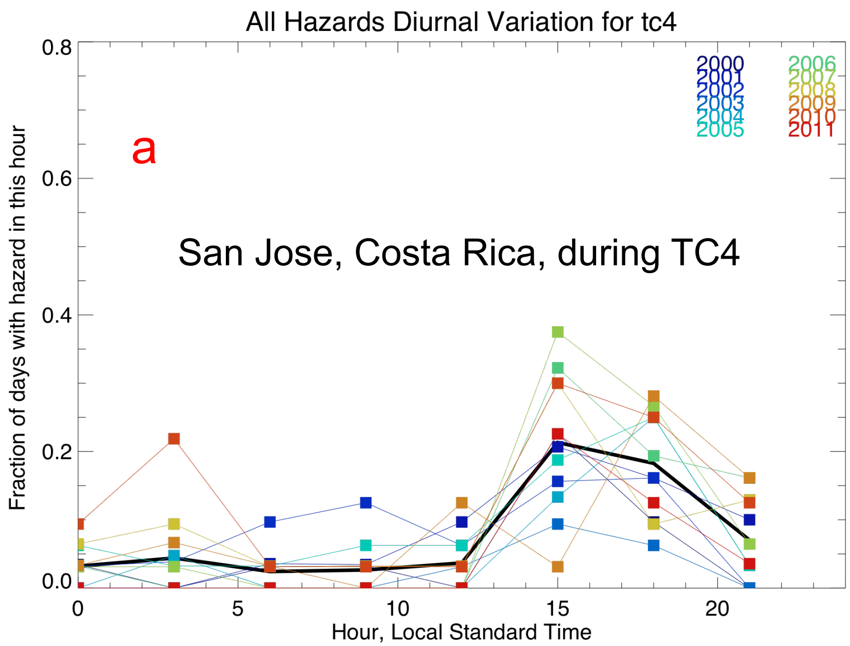
Rain Days in Month (#)

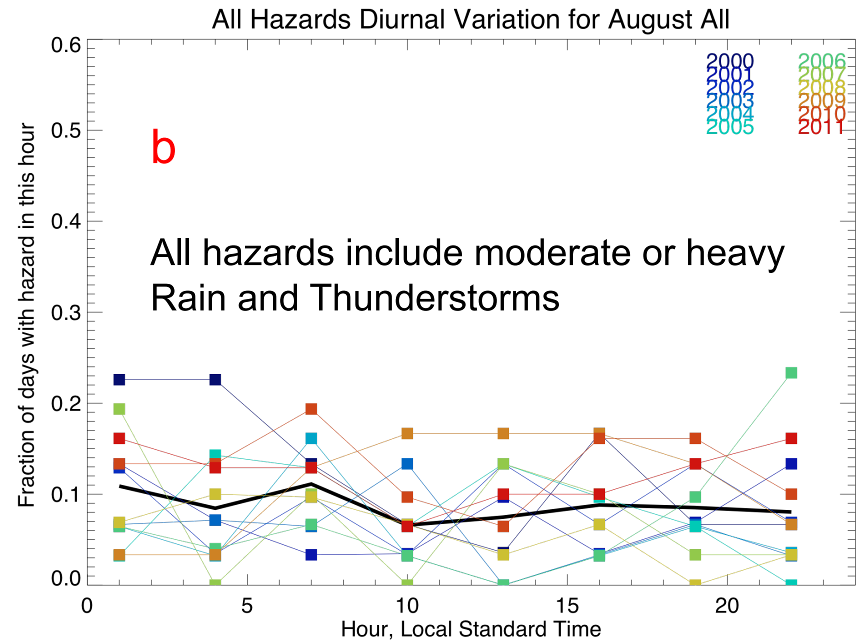
	July	August	Sep	Oct
San Jose	13.7	14.5	18.1	17.9
Sattahipp	8.2	8.7	11.9	13.5

T-storm Days in month (#)

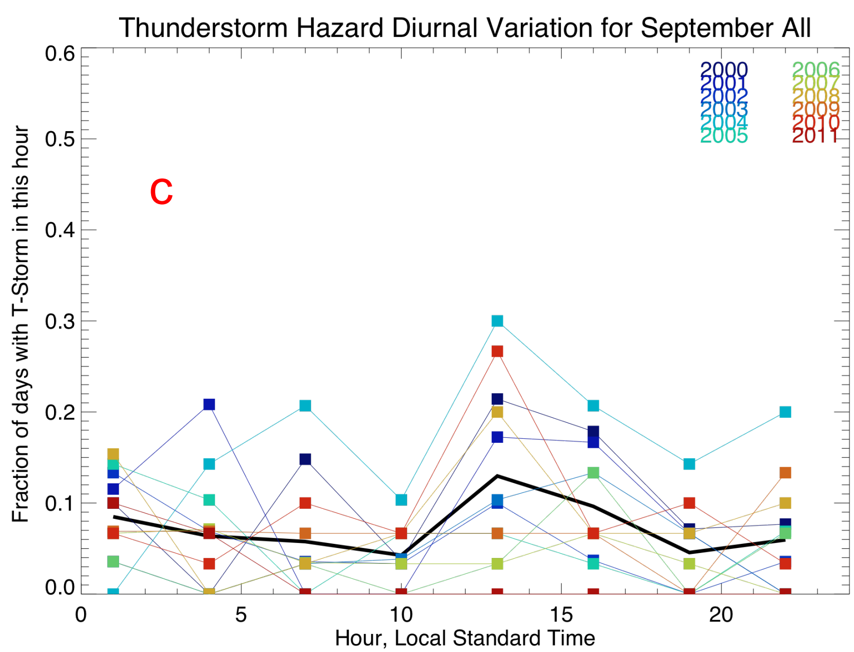
	July	August	Sep	Oct
San Jose	5.0	5.0	10.0	6.0
Sattahipp	5.0	5.0	8.0	12.0

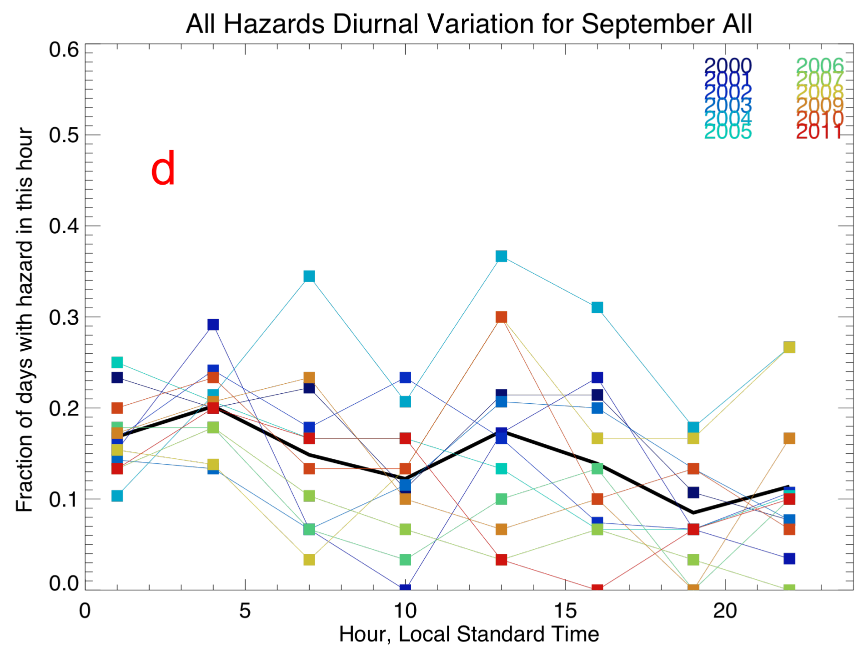
- Wind hazard not an issue in Utapao
- Fog not an issue in Utapao
- August generally less rain than SJ
- September rain days and rainfall comparable to SJ
- T-storms and other hazards greater in September than August.
- More T-storms in September in Utapao than in San Jose during TC4.
- Coastal station, so diurnal cycle is not as strong as at SJ (compare a in next slide to b,c,d). There appears to be both a morning peak and an early afternoon peak (d in next slide)
- Interannual variability in lightning and thunderstorm activity is strong – La Nina periods appear to be the most active (but correlation is not strong).
- TRMM rainfall stats show highest rainfall from noon to 3 PM.

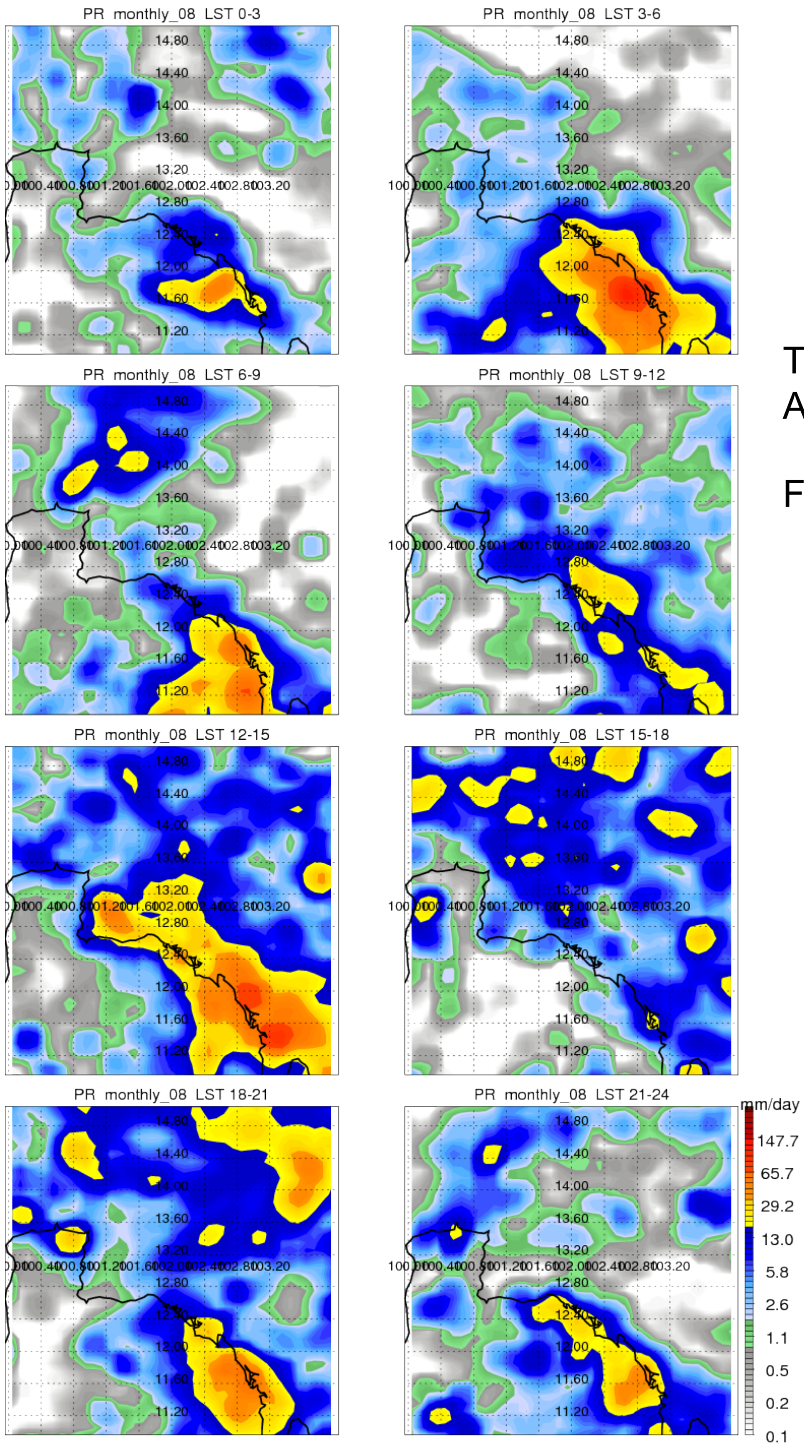




Statistics based on CDC 3-hourly weather observations at Ben Sattahipp and San Jose

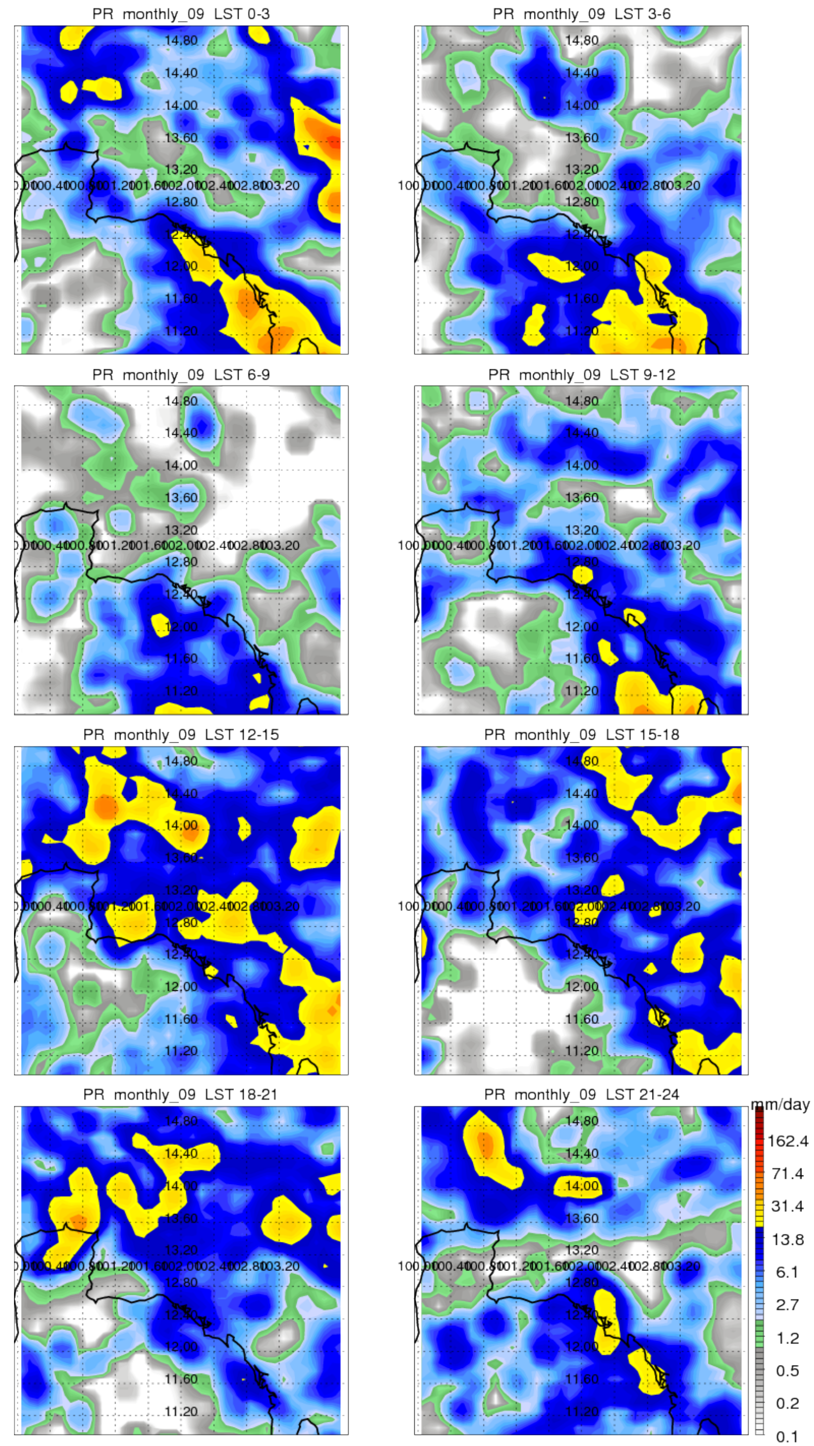




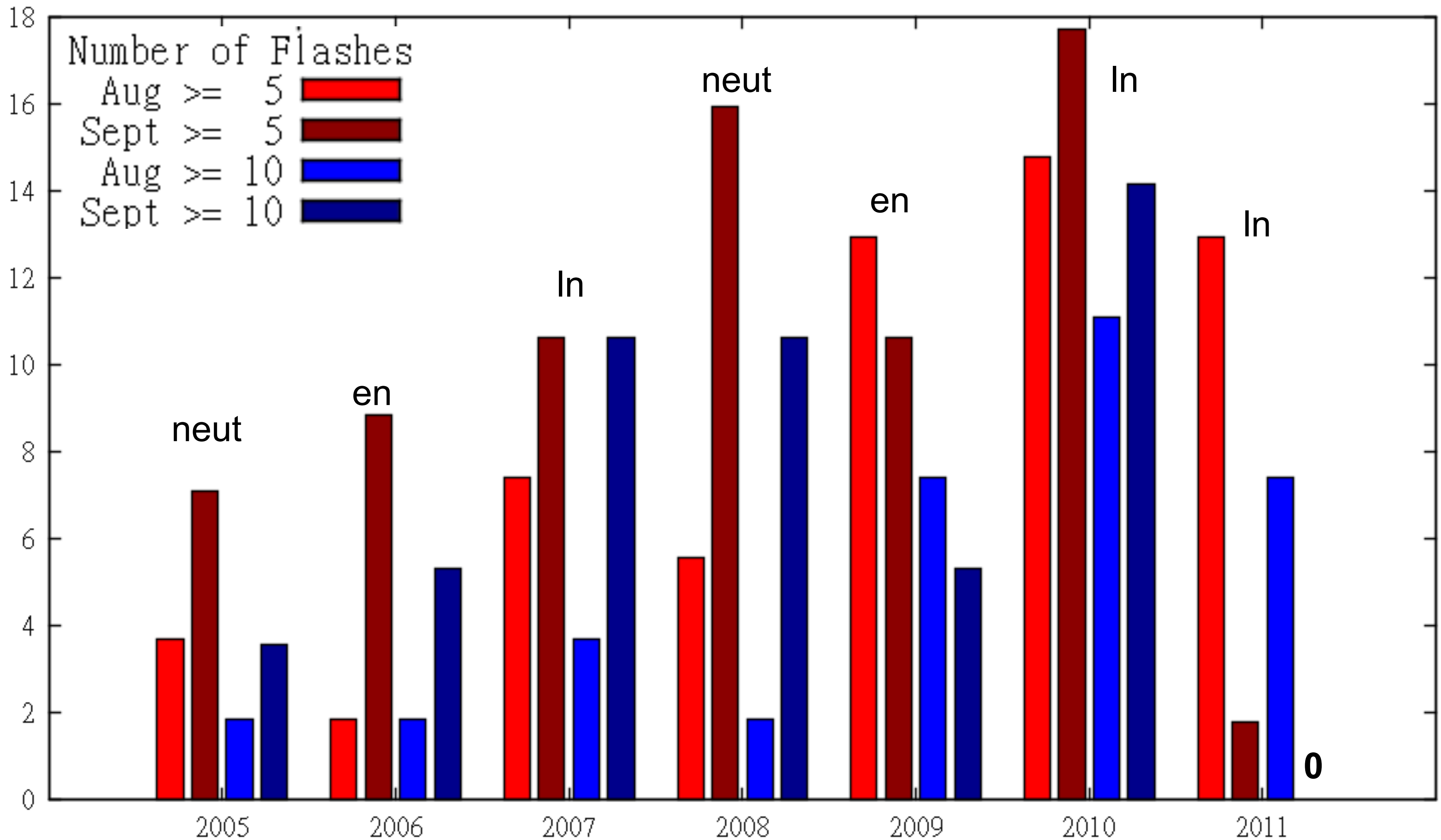


Trmm diurnal rain:
Aug (left); Sep (rgt)

From Chuntao Liu

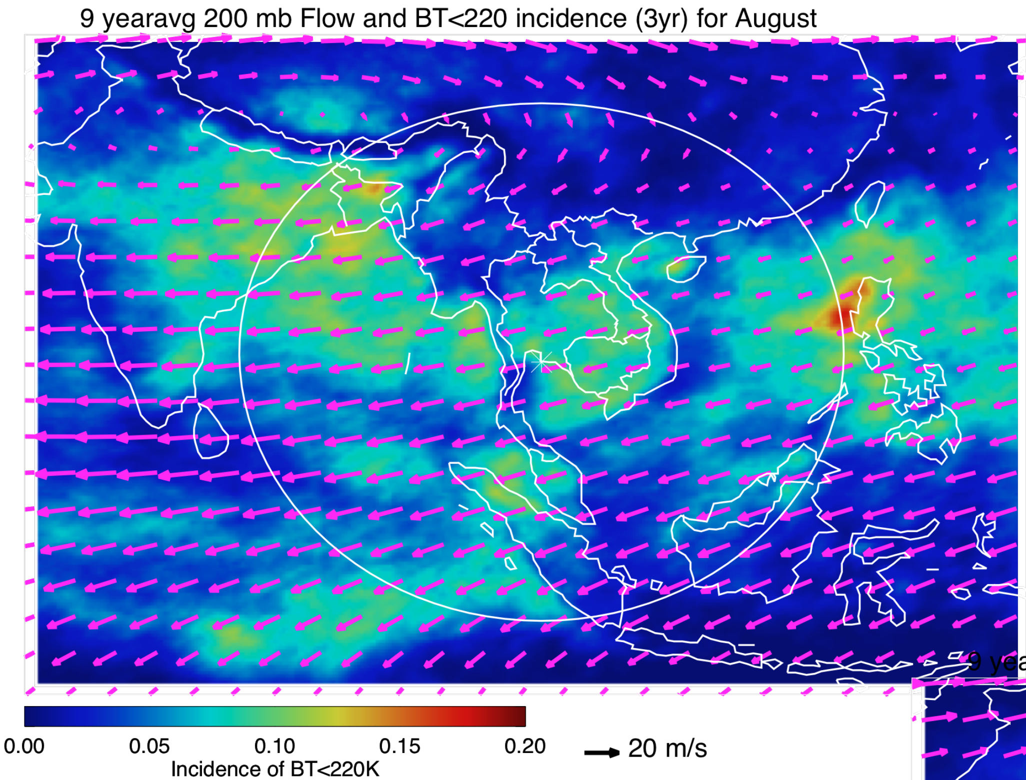


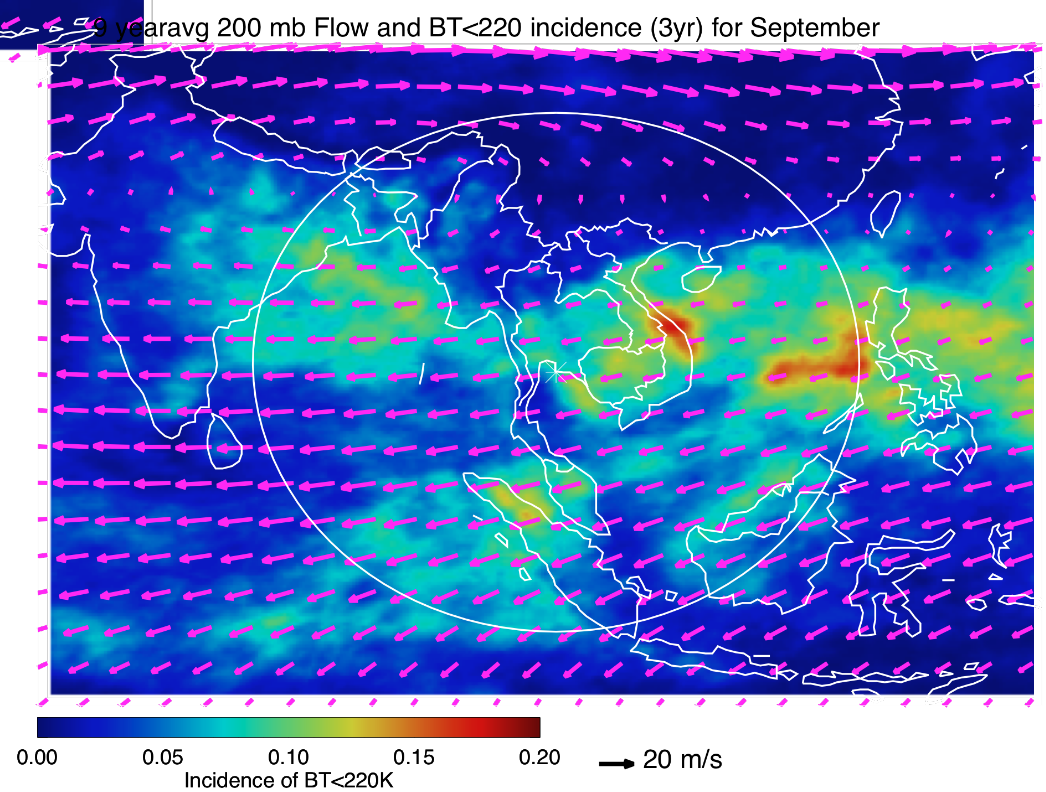
Days With ≥ 5 or ≥ 10 Flashes in a 30×30 km Box Centered on U-TaPao



Summary

- Persistent westerly mean flow throughout region at low levels – mean precip strongest just upstream of topography over oceans.
- Cold cloud regions – strongest over Bay of Bengal in August, clearly shifting eastward and southward in September
- Upper levels – strong anticyclone over Tibet, with easterly jet over India/SE Asia. Anticyclone weakens in September, especially toward the end.
- Diurnal variability – about 20% of precip variance. Stronger in September over SE Asia. Late afternoon max over land, early morning max over ocean. Significant diurnal variability even over Bay of Bengal. Propagating convection from Sumatra, Philippines, Borneo.
- Lightning – stronger in September than August – strong diurnal variability. Focus is on Malaya/Sumatra/Straits of Malacca.
- ENSO – most overall precip variability is near equator (Indonesia). Enso index negatively correlated with precip. TC incidence varies also, but correlation is not as "reliable."
- Intraseasonal/day-to-day variability. Tropical cyclones, easterly waves/MRG, MJO, Equatorial Rossby Waves, and equatorial Kelvin waves all play a role.
- Origin of air within 100mb anticyclone: August – consistent with rising motion over BOB region, with air coming from western Indian ocean. September – more convection further east leads to higher incidence of air origin from Pacific.
- Utapao weather.   Major issue is thunderstorms, which are more of a problem (usually) in September than August. Diurnal cycle is weaker than in San Jose.





Anticyclonic flow, broad easterly jet over our region. Weakens slightly in September

Note shift in cold cloud to the east and over Borneo